CRUISE REPORT[1]

VESSEL: *Oscar Elton Sette*, Cruise 04-04 (OES-13) (Fig. 1)

CRUISE PERIOD: 21 March- 9 April 2004

AREA OF OPERATION: U.S. Line Islands: (Jarvis Island, Palmyra Atoll, and Kingman Reef)

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Island Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), NOAA, conducted coral reef assessment/monitoring and mapping studies in waters surrounding the U.S. Line Islands of Jarvis, Palmyra, and Kingman.

ITINERARY:

16-21 Mar Start of cruise. *Oscar Elton Sette* arrived Pago Pago Harbor, Tutuila, American Samoa to complete OES-04-03. Began reloading of CRED items stored at harbor facility. Embarked Robert Schroeder (fish). Craig Musburger (fish) and Kyle Hogrefe (towboard/habitat) remained onboard from previous leg. CRED Research Vessel *AHI* (Acoustic Habitat Investigator) reloaded onto *Sette* for transit back to Honolulu. Loaded fuel drums. Embarked Megan Moews (benthic habitat mapping), Mark Readdie (fish), Kim Page (algae), Linda Preskitt (algae), Jean Kenyon (coral), Jim Maragos (coral), Scott Godwin (invertebrates), Ron Hoeke (oceanography), Kevin Wong (oceanography), Jamie Gove (oceanography), Joe Laughlin (towboard/fish), Marc Lammers (benthic habitat mapping/bioacoustics), Russell Moffitt (data management), Alex Wegmann (terrestrial), Mark Rauzon (terrestrial), Stephani Holzwarth (towboard/fish), and Molly Timmers (towboard/habitat). Departed Pago Pago Harbor 21 March at 0900 en route to Jarvis Island. Conducted shipboard orientation meeting for all scientists. Conducted ship's fire and abandon ship drills.

22-25 Mar Transit to Jarvis Island. Conducted dive safety management meeting (including accident reporting requirements); new scientists experienced decompression chamber. Scientists set up computer work stations and network and prepared field survey gear and equipment. Fish and benthic rapid

[1] PIFSC Cruise Report CR-05-004
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ecological assessment (REA) teams met and worked out site selections for Jarvis. Arrived Jarvis ~ 2300.

26 Mar Conducted six towed-diver habitat and fish surveys around most of the island and three fish and benthic REA surveys on the E and N sides. Deployed four subsurface temperature recorders (STRs) and recovered old/deployed new ocean data platform (ODP). Night ops conducted six deep conductivity-temperature-depths (CTDs) around the island. Drop-off too steep to conduct tethered optical assessment device (TOAD) surveys around Jarvis. U.S. Fish and Wildlife Service (FWS) terrestrial survey team of two went ashore to spend the night and conduct dusk/dawn bird surveys.

27 Mar Conducted five towed-diver habitat and fish surveys and three fish and benthic REA surveys on the S and W sides. Fish REA and Tow teams collected fish specimens (as per permit). Deployed new sea surface temperature (SST) buoy and retrieved old anchor from lost buoy; completed 34 shallow water CTDs around island. Picked up two terrestrial biologists from island. Night ops included deep CTDs around the island and three bioacoustic lines. Departed Jarvis for Palmyra.

28 Mar Transited to Palmyra. Scientists drafted reports summarizing preliminary findings at Jarvis. Bioacoustic echosounder data on the deep scattering layer were collected intermittently during the transit.

29 Mar *Oscar Elton Sette* arrived at Palmyra ~1000 and launched boats. FWS team went ashore late AM for an extended stay. REA teams completed two stations (one a permanent transect) surveying fish, corals, algae, and invertebrates. Fish team collected specimens. Tow team completed five fish/habitat tows along the S. Mooring team recovered an STR in SE backreef ("coral gardens" site) and replaced it with a new one; deployed a subsurface temperature recorder (STR) off SE corner of island and conducted 16 shallow conductivity-temperature-depths (CTDs) along S side. During night, conducted tethered optical assessment device (TOAD) surveys on W bank, deepwater CTDs, and bioacoustics lines.

30 Mar REA teams surveyed three stations to SW of atoll. Fish team collected about 2 dozen more fish specimens for genetic analysis. Tow team completed six tows along the western bank. Mooring team deployed a new Coral Reef Early Warning System (CREWS) buoy in the lagoon, retrieved the previous CREWS buoy from shore, and conducted nine shallow CTDs. FWS team continued work ashore. Night ops included TOAD, deepwater CTDs around the atoll, and bioacoustic lines.

31 Mar REA teams surveyed three sites - two in SE and one on W (large bumphead parrotfish [*Bolbometopon muricatum*] sighted in "coral gardens" station). Tow team completed four tows along the N and W sides (all divers required to be out of water from 1300-1500 for ship's crew to conduct NOAA proficiency dives; and also had some engine trouble). Mooring team completed 18 CTDs outside

the atoll and deployed one STR. Depths contour along SE and E sides too irregular and steep to permit safe TOAD operations.

1 Apr REA teams conducted surveys on S side and far NW terrace (winds continued too strong for REA teams to work the N and NE sides of atoll). Tow-team completed all planned tows around the outside of atoll, except along the high surf zone eastern side. Daytime bioacoustics baseline transects ran for Palmyra. Mooring team conducted 12 CTDs around the atoll and in the lagoon, plus radiometer readings in lagoon. Night ops included deep-water CTDs and bioacoustic lines. Terrestrial survey team member M. Rauzon returned to the ship after successfully completing his work ashore; other member (A. Wegmann) remained on Palmyra to conduct long-term thesis research.

2 Apr Transited from Palmyra to Kingman (arrived ~ 0730). REA teams surveyed sites along the S arm - two outside and one inside. Tow team completed six tows along S and part of W arms outside barrier reef. Mooring team exchanged settling plates on CREWS-buoy anchor in SE corner of lagoon and placed a STR there, retrieved current meter from the S pass channel, and placed a STR there and conducted nine CTDs along the inside of the E arm. No TOADable depths found at Kingman. Bioacoustics and deep CTDs around outside of atoll conducted during night operations.

3 Apr REA teams surveyed two sites inside the SE corner of atoll (both permanent transects) and one site inside the S island (inner reef slope). Tow team completed six tows on E side (three outside and three inside the NE). Mooring team conducted 23 CTDs along the S side (inside and out) and placed two STRs. Terrestrial team searched for amphipods on small island along NE arm. Night CTDs ended early as ship's CTD winch experienced mechanical problems.

4 Apr REA teams surveyed backreef slope along NE arm and two patch reefs (one a permanent transect) inside lagoon. Tow team completed six tows inside lagoon, which completed resurveys of all previous year's tows at Kingman. Mooring team conducted 13 CTDs and placed several STRs, both inside and outside the atoll. Ship conducted two bioacoustic baseline lines during daytime. In evening conducted two deep CTDs from ship - one on NW and one on N. Completed all field surveys for the cruise, with addition of several bioacoustic lines to be run intermittently during the transit home. Ship departed Kingman Atoll for Honolulu at ~2130.

5-9 Apr Transited to Honolulu. On 9 April, between 0000 and 0500, an opportunistic bioacoustic transect was conducted along the Waianae coast of Oahu in waters between the 10- and 50-fathom isobaths. Baseline acoustic backscatter data from the local mesopelagic boundary community were collected to provide a comparison with the data obtained from other locations surveyed during the cruise.

Table 1: Cruise summary statistics for the U.S. Line Islands.

CRUISE SUMMARY STATISTICS (US Line Islands):

Field Activity	Jarvis Island	Palmyra Atoll	Kingman Reef
Towed Diver Fish/Habitat Surveys	10	21	18
Fish REAs	6	10	9
Benthic REAs	6	10	10
CREWS buoy recovery/deployment	0	1	1 (recov.)
ODP recovery/deployment	1	0	0
SST buoy recovery/deployment	1	0	1
STR deployments	4	4	5
TOAD drop camera surveys	0	20	0
Aanderaa current meter recovery	0	0	1
Settlement/recruitment plate recovery/ deployment	1 (depl.)	1	1
Shallow water Radiometer casts	0	9	5
QTC acoustic habitat surveys	0	20	0
Bio-acoustic transects (hr)	12	18	12
Deepwater CTDs	13	12	8
Shallow water CTDs	35	55	45
SCUBA dives	87	145	133

MISSIONS AND RESULTS:

A. FISH: Used established quantitative methods (belt-transect, SPCs, REAs) to estimate fish stock biomass and fish species richness, respectively, at habitat-representative stations, to contribute to an expanded baseline assessment and implement monitoring for temporal changes. This was the first year SPCs were conducted throughout the U.S. Line Islands. Select specimens were collected for genetic analysis as requested by collaborators (by permit). (See Appendix A.)

Totals of 6, 10, and 9 stations were resurveyed (monitoring) by the 3-diver Fish REA Team at Jarvis, Palmyra, and Kingman, respectively. Our general impression was that fish assemblages were basically similar to those found on previous CRED cruises at all three reefs, quite healthy with a significant apex predator present at most sites. Common families included sharks, rays, squirrelfish, groupers/anthias, jacks, snappers, butterflyfish, angelfish, damselfish, wrasses, parrotfish, and surgeonfish. The total numbers of fish species observed in 2004 were 171 at Jarvis, 209 at Palmyra, and 165 at Kingman. At Jarvis, small planktivores (e.g., *Anthias*) were very abundant, especially along the W side and on the SE reef terrace. Sharks (mostly gray reef and white tips) were also common here. At Palmyra, large fish were abundant but less so than at Jarvis. At Kingman, fish assemblages generally remain healthy, however, overall fish density, for both small and especially large fish appeared lower than before, with some exceptions. An average of only about one or two sharks were seen during

each dive, compared to about a dozen sharks observed on a typical REA dive 2 yr ago. Select fish specimens collected for genetic analysis totaled 34 at Jarvis, 68 at Palmyra, and 55 at Kingman.

B. CORALS: Conducted surveys to document the species composition, abundance, percent cover, size distribution, and general health of the shallow water corals in the U.S. Line Islands. (See Appendix B.)

Totals of 6, 9, and 9 stations were resurveyed (monitoring) by the Coral REA Team at Jarvis, Palmyra and Kingman, respectively. Visual estimates of percent live cnidarian cover ranged from 5% to 75%. In general, corals remained healthy, or were recovering, except on exposed, storm-impacted N or E sides. The total numbers of stony coral genera observed in 2004 were 20 at Jarvis, 36 at Palmyra, and 37 at Kingman. The lower value for Jarvis reflects the lack of atoll-type reef habitat. At Jarvis, *Pocillopora* and *Montipora* dominated, each genus contributing more than 20% of the total number of coral colonies. At Palmyra, the genera *Pocillopora, Porites,* and *Pavona* dominated, each contributing >10% of the total number of colonies. The eastern reef pool site, "coral gardens," continues to have high diversity and lush proliferation of *Acropora* corals. At Kingman, *Fungia* and *Porites* dominated, each genus contributing 42% and 23% of the total number of colonies, respectively. Coral communities remain healthy and diverse, despite heavy predation observed in 2004 from the crown-of-thorns seastar *Acanthaster*.

C. ALGAE: Used quantitative photoquadrat sampling method to collect species composition and baseline abundance data of reef algae in the U.S. Line Islands to compare with previously collected qualitative samples. (See Appendix C.)

Totals of 6, 10, and 10 stations were surveyed by the Algae REA Team at Jarvis, Palmyra, and Kingman, respectively. Red turf and crustose coralline algae were very common at each of the U.S. Line Islands visited with an average occurrence in photoquadrats of 95.4% for turf and 89.6% for crustose coralline. At Palmyra and Kingman, the most abundant frondose algae were multiple species of *Halimeda* occurring in 70.8% and 71.3% at the respective islands. Jarvis was characterized by a high abundance of the encrusting brown alga *Lobophora variegata* which occurred in 69.44% of the photoquadrats. *Dictyosphaeria cavernosa* as well as an unidentified orange encrusting alga were common at Palmyra occurring in 26.4% and 65.6% of the photoquadrats, respectively. At Kingman Atoll, *Microdictyon* sp. was a dominant macroalga occurring at 34.26 % of the sites visited.

D. INVERTEBRATES: Surveyed non-coral marine invertebrate fauna to assess their relative abundance and monitor of reef communities to identify changes. This is accomplished through procedures that quantify a set of target organisms and build a species inventory to document biodiversity. (See Appendix D.)

At Jarvis, populations of macroinvertebrates were diverse and abundant and remain healthy since last surveyed in 2002. The unique set of oceanographic conditions at this island allow more than adequate larval recruitment and primary

productivity to support such assemblages of mobile and sessile reef invertebrates. Palmyra Atoll's wealth of habitats supports varying degrees of macroinvertebrate diversity. Giant clams (*Tridacna maxima*) were generally not very abundant, except on the shallow sheltered "coral gardens" reef. Crown-of-thorns starfish (*Acanthaster planci*) were rarely seen. A focused survey for marine alien marine invertebrate species was conducted within the lagoon. Alien species found included a hydroid (*Pennaria disticha* [confimed]), and two species of sponge (suspected). Kingman Reef exhibits an extreme abundance and diversity of macroinvertebrate species within all forereef, backreef, and patch reef habitats; all populations appeared intact and undisturbed by man. The giant clams *Tridacna maxima* (most common) and *Tridacna squamosa* were present in all habitats surveyed, most dense on lagoon patch reefs. Echinoderms were also common throughout the atoll, represented by all classes (except crinoids); greatest abundance was on lagoon reefs. The crown-of-thorns starfish was recorded at all survey sites, suggestive of a high potential for large outbreaks in the near future.

E. TOWED-DIVER SURVEYS: Used benthic and fish towed-diver survey methods in the U.S. Line Islands to provide a general description of reef habitat, macro-invertebrates, and reef fishes over a large spatial scale. The methods provided assessments and the foundation for monitoring large-scale disturbances and general distribution and abundance patterns of macroinvertebrates and reef fishes over 50 cm total length. (See Appendix E.)

Totals of 11, 21, and 18 towed diver surveys were conducted around Jarvis (20 km), Palmyra (41 km), and Kingman (39 km), respectively. <u>*Benthic Observations*</u>: Habitat surveys found 0.1%, 0.7%, and 1.5% of the corals to be pale in appearance at these three reefs, respectively. Few conspicuous macroinvertebrates were found at Jarvis and Palmyra, no crown-of-thorns, and only few giant clams at Palmyra. However, at Kingman crown-of-thorns were abundant (~50 COT/tow; a 66% increase over 2002 surveys). About 15% of the corals appeared white from likely predation. Also at Kingman, over 25,000 giant clams (*Tridacna sp.*) were observed, 85% in the southeast backreef lagoon, composing nearly 50% of the benthic substrate here. Soft corals were observed in a few places (e.g., sites of storm damage) at Jarvis and Palmyra, while they dominated the forereef on two sides of Kingman. <u>*Fish Observations*</u>: The twin spot snapper (*Lutjanus bohar*) was the most commonly observed fish, larger than 50 cm TL at all three reefs. Also common were gray reef shark (*Carcharhinus amblyrhyncos*), rainbow runner (*Elagatis bipinnulata*), and pacific steephead parrotfish (*Chlorurus microrhinos*). At Jarvis, blacktongue unicornfish (*Naso hexacanthus*) and blackfin barracuda (*Sphyraena qenie*) were also common. At Palmyra several large (>3 m TL) giant hammerhead shark (*Sphyrna mokarran*) were seen and a large (>4 m TL) tiger shark (*Galeocerdo cuvier*) was sighted at Kingman.

F. OCEANOGRAPHIC SURVEYS: Conducted near and offshore oceanographic surveys and deployed a variety of surface and subsurface oceanographic instruments in the U.S. Line Islands with the goal to quantify and assess and gain a better understanding of the overall hydrographic environment near these islands. (See Appendix F.)

At Jarvis, strong flow of the Equatorial Undercurrent (EUC) past the island results in upwelling of cold water on the western side. This injection of cold, nutrient rich water likely has important ecological impacts on the local coral reef ecosystem. Preliminary analysis of shallow water CTD data shows generally warm (27.0 to 27.3^{o}C) and well mixed waters to the SE, E, and N sides of Jarvis. Temperature profiles showed signs of upwelled west and southwest EUC waters in 2004 (i.e., 0.3 to 0.7˚C colder than surrounding waters).

At Palmyra, preliminary analysis of shallow water CTD shows surrounding waters to have a mean temperature of 28.0˚C and mean salinity of 34.7 PPT. Waters were generally well mixed and extremely clear (transmissivities >80%), except in the lagoon.

Kingman Reef has no significant emergent reef or land and its lagoon appears to be extremely well flushed. Preliminary analysis of shallow water CTD shows surrounding waters are extremely well mixed, with a mean temperature of 28.1˚C and mean salinity of 34.6 PPT; all transmissivities were greater than 80%. Except for small sheltered areas of the lagoon, CTD characteristics inside the reef or relic lagoon were nearly indistinguishable from those outside the lagoon, which leads to the assumption that Kingman Reef's lagoonal waters are nearly pelagic most of the time. Maximum recorded temperatures reach approximately 30.2˚C and minimum temperatures are approximately 27.5˚C.

G. NIGHT SURVEYS: Towed Optical Assessment Device (TOAD) to videotape portions of the seafloor, and QTC (benthic acoustic signature) data were collected at Palmyra, but not at Jarvis or Kingman, due to steeply dropping depths adjacent to the shallow reefs. The ship's acoustic doppler current profiler (ADCP) was still not functioning. Conductivity-temperature-depth (CTD) casts and bioacoustic (echosounder) lines were conducted (See Appendix G).

At Jarvis Island, CTD profiles show characteristic water properties of the EUC with distinctively marked decreases in temperature and dissolved oxygen coinciding with an increase in salinity. The CTD cast to the East of Jarvis exhibited a much different profile. Temperature, dissolved oxygen, and salinity show a homogenization of the upper 100 meters, with a more gradual change in values over the next 50 meters. A nonquantitative assessment of the bioacoustic data revealed a clear diurnal trend in the occurrence of a layer of surface-associated biomass.

At Palmyra Atoll, TOAD was deployed 20 times in conjunction with the QTC data collection. The expansive western bank consisted primarily of extensive amounts of diverse live corals which sometimes alternated with fields of coral rubble and encrusting coralline algae with small patches of live coral. The benthic topography in these areas was rough textured with many overhangs and large coral heads. Most of the CTD data around Palmyra show a decrease in salinity at the surface. A nonquantitative assessment of the bioacoustic data revealed that a dense community of mid-water sound scattering organisms exists around the entire perimeter of the atoll at night. From our observations it can be

speculated that the SW side of the atoll is enriched by nutrients flowing out of the lagoon more so than the other sides. Coincidentally, several observations of melon headed whales (*Peponocephala electra)* were made along this side of the atoll. This species is known to feed primarily on squid, which are typically part of the sound scattering layer.

At Kingman Reef, CTD casts show similar patterns to Palmyra. Kingman profiles show a shallower thermocline starting at ~100 meters. At most of the stations, the salinity tends to be mixed to 100 meters. The most prominent patch was observed along the SW corner of the atoll and coincided with the entrance to the primary channel to the atoll.

The echosounder data collected at the three sites visited reveal that each location is quite distinct in the density and distribution of the mid-water biomass occurring there. Jarvis and Palmyra appear to be much more productive than Kingman. Furthermore, only Palmyra supports a dense, thermocline-associated community. The three locations are quite distinct oceanographically and ecologically. Jarvis is fed by upwelling and is also a major bird colony. Nutrient inputs from these two sources probably contribute to the productivity observed there. Palmyra is a forested network of islets that also supports a significant bird population. Nitrogenous and organic outflows from the terrestrial ecosystem are likely important factors influencing the productivity observed there. Kingman has neither of these major influences, which may explain the lack of sound scattering biomass encountered there.

H. TERRESTRIAL SURVEYS: The terrestrial team conducted pelagic bird and mammal transects during transit between islands. On shore, a standard rapid ecological assessment of the islands were made by counting and staging all active nests of breeding seabirds, counting wintering shorebirds, listing all plant species, and recording their phenological condition as well as looking for other biological phenomena and signs of trespass or introductions of nonnative invasives. (See Appendix H.)

At Jarvis, over 1.5 million birds were counted representing about 19 species. The island was very dry and the vegetation was brown. About 100-150 bottlenose dolphins were seen around the atoll. The health and growth of bird populations here may be related to the oceanic upwelling around the island that promotes their planktonic food sources.

At Palmyra, over the past decade, there has been a rapid decline of its (previously undisturbed) *Pisonia* rainforest caused by an infestation of a scale insect. As the *Pisonia* forest declined and the dense shade provided by the canopy eliminated, dense undergrowth of fern and sprouting palm nuts may change the microclimate of the forest floor. The forest ecology is jeopardized by the loss of the giant trees. It remains unknown what effect this loss will have on reef nutrient enhancement around the atoll.

At Kingman Reef, only the eastern tip of the reef is above water, and there are two small isles (few 100 m^2 each) composed of clamshell and coral rubble. About six species of birds were sighted.

SCIENTIFIC PERSONNEL:

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DATA COLLECTED:

Fish REA numerical and biomass densities by species
Fish specimens for genetic analysis
Digital images of fish-habitat associations
Target REA macroinvertebrate counts
Macroinvertebrate voucher specimens
Algal voucher specimens
Algal REA field notes of species diversity and relative abundance
Digital images from algal photoquadrats
Quantitative towboard surveys of large fish species (>50cm TL)
Digital video surveys of fish from towboard transects
Benthic composition estimations from towboard surveys
Macroinvertebrate counts from towboard surveys
Digital images of the benthic habitat from towboard surveys
Habitat lineation from towboard surveys

Videos of the deeper benthic habitats/biota from TOAD operations
QTC (benthic acoustic signature) data
Shallow-deep conductivity, temperature and depth (CTD) profiles
Bioacoustic (echosounder) transects of sound-scattering layers
Terrestrial bird and mammal surveys

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Attachments

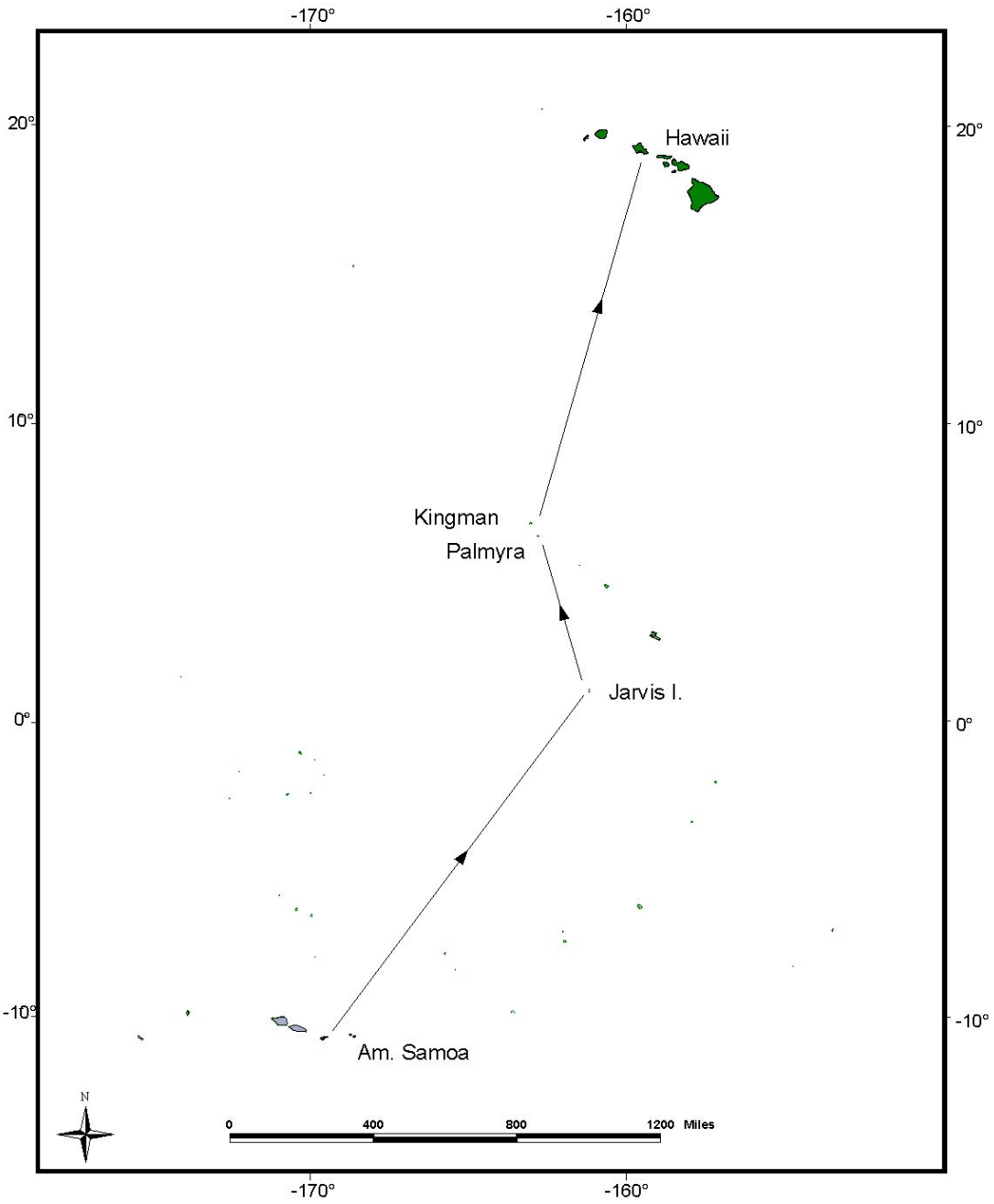

Figure 1. *Oscar Elton Sette* cruise track through U.S. Line Islands, 21 March-9 April, 2004.

APPENDICES

Appendix A: Fish Rapid Ecological Assessment (REA) Team Activity Summary

(Robert Schroeder, Craig Musburger, Mark Readdie)

A. Methods

Fish transect stations consisted of three consecutive 25-m lines set along a single depth contour at 13–15 m. As each line was set, the observers swam about 5 m apart along each side of the line, counting and recording size classes for all fishes >20-cm total length (TL) within an area 4 m wide and 4 m high. At the end of each 25-m line, the divers turned around and, while remaining on either side of the line, began counting and recording size classes of all fishes within 2 m of their side of the line and 4 m off the bottom. Four stationary point counts were made at each transect station, generally ~15 m from the transect line. SPCs consist of the diver counting and recording the size classes for all fishes >25 cm total length observed in the water column within a cylindrical volume 10 m in radius during a 5-minute period. In addition, the divers recorded the species of fishes seen outside the transect area and outside the SPC counts on an opportunistic basis. During REA surveys, the divers record all species observed during the dive. These observations of diversity are combined with fish observed by other divers (benthic team, tow team, or mooring team) to develop an island-wide listing of all fishes observed.

B. Results

1. Jarvis Island

From 26 to 27 March, 2004, the fish census team surveyed six total stations covering all sides of the island. Habitats included the exposed outer reef slope, with one site being an expansive reef terrace off the SE side of the island. These six stations all were resurveys ("monitoring") of sites established by CRED in February of 2002 or 2001. Quantitative belt transects (BLT), stationary point counts (SPC), and qualitative REA surveys (for species presence) were conducted at each of these sites, using the same methodology as in 2002 and summarized below. This is the first time complete SPCs were conducted in the U.S. Line Islands. The benthic team (corals, algae, invertebrates) followed the fish team at all sites.

Our general impression (pending statistical confirmation) was that fish assemblages were basically similar to that found in CRED's 2002 cruise, quite healthy with a significant apex predator presence . Large fish density remained high at all sites. Sharks (mostly gray reef and white tips) were common, but seemed to be slightly less common along the W than 2 years ago. Planctivores were very abundant, especially along the W side and on the SE reef terrace.

The total number of coral reef fish species CRED documented in 2002 for Jarvis was 146. The total number of species we observed in 2004 was 171, this time with three diver-observers (rather than only two) and one extra station (compared to 2002).

The east side (sites 10 & 1) consisted of an expansive relatively flat reef terrace with a gradual slope and near 90% dead coral and rubble. The north side (site 8) was mostly dead coral rubble on about a 45^{o} angle slope. The south side (site 4) had high hard coral cover on a steep slope. The west side of the island (sites 7 and 11) was characterized by steep drop-offs with high soft and hard coral cover. Ocean conditions varied. East and northeast sites had 10-15-kn winds, 4-5-ft surge and current, >1 kn at site 10. The south and west sides were more protected with 5-10-kn winds, 1-3-ft surge and negligible current. Underwater visibility was about 40-50 ft at all sites, except site 11, with 30-40 ft visibility. Water temperature was fairly consistent at 80-81^{o}F. Jarvis is known to have an equatorial counter current that causes an upwelling along the W side, which presumably creates a highly productive ecosystem.

The quantitative fish data may not be fully representative at station JAR-10 (top of east terrace, ~35 ft deep), as we were hampered by current, strong surge, numerous large sharks, and insufficient time. Possibly moving this SE site more seaward into deeper water (~50 ft) where the slope begins would eliminate some of these hindrances. (Similar conditions in 2002 precluded the collection of quantitative data at this site as well.)

Fish Family Summaries

A total of 171 species from 36 families were observed at Jarvis by both the Fish REA team and the Fish Tow Team. Following is a brief synopsis of some of the more common families.

Sharks (Carcharinidae, Rhincodontidae and Sphyrnidae):

Sharks were quite abundant at Jarvis. Density was highest and individuals were largest along the eastern slope – especially at the site at the southeast. Grey reef (*Carcharinus amblyrhynchos*), reef whitetip (*Triaenodon obesus*), and reef blacktip (*C. melanopterus*) sharks were most common. It was common to observe 10 or more sharks ranging in size from 130 to 180 cm at any site. The REA team observed a single 300-cm great hammerhead (*Sphyrna mokorran*), and the tow team observed a school of 15 individuals ranging from 10 to 15 feet. The tow team also observed one 15-foot whale shark (*Rhincodon typus*) from their boat.

Rays (Mobulidae):

Manta rays (*Manta birostris*) were observed commonly around Jarvis. Most individuals had wingspans between 6 and 10 feet with the occasional larger individual up to 14 feet. They were observed singly and in small groups of 3-5 individuals.

Soldier/Squirrelfish (Holocentridae):

Sites along the western side supported exceptionally high densities of soldier/squirrelfish. Bigscale soldierfish (*Myripristis berndti*) were most common with many individuals exceeding 20 cm in length. Also abundant were blue-lined squirrelfish

(*Sargocentron tiere*), and lesser tailspot squirrelfish (*S. caudimaculatum*), and sabre squirrelfish (*S. spiniferum*).

Groupers/Anthias (Serranidae):

Groupers were very abundant at all sites surveyed. Most common were flagtail grouper (*Cephalopholis urodeta*), coral hind (*C. miniata*), and peacock grouper (*C. argus*). One grouper of questionable identification was repeatedly observed along the west side (see Species with Uncertain Identifications [below] for complete description). At the site in the northwest, a dense aggregation of this grouper species was observed in what was presumed to be courtship behavior. Lyretail grouper (*Variola louti*) were common and very large at sites on the south and west sides. Several individuals in excess of 50 cm in length were observed.

Anthias were among the most abundant fish on the reefs at all sites. Bartlett's anthias (*Pseudanthias bartlettorum*), and associated mimic species were observed in massive clouds above the reef along nearly all transects. It was not unusual to observe schools in excess of 1000 individuals along a reef crest. Also abundant was the yellowtail anthias (*Pseudanthias olivaceus*).

Jacks (Carangidae):

Jacks were common at all sites. The most common species was the black jack, (*Caranx lugubris*). Also abundant were bluefin trevally (*C. melampygus*) and rainbow runners (*Elagatis bipinnulata*). One giant trevally (*C. ignobilis*) was observed along the south side.

Snappers (Lutjanidae) and Emperors (Lethrinidae):

With the exception of the twinspot snapper (*Lutjanus bohar*), snappers were not very abundant at any site. Individual twinspot snapper were quite large with some in excess of 70 cm. Smalltooth jobfish (*Aphareus furca*) were occasionally seen, and one site hosted an aggregation of blue-lined snapper (*L. kasmira*).

Emperors were rare with the bigeye emperor (*Monotaxis grandoculis*) being observed at several sites and a few individual yellowspot emperors (*Gnathodentex aurolineatus*) hovering among the school of blue-lined snapper mentioned above.

Butterflyfish (Chaetodontidae):

Butterflyfish were conspicuously rare at all sites. While 13 species were observed, sightings were usually limited to one or two individuals of each species, and sightings were infrequent. Most common were the raccoon butterfly (*Chaetodon lunula*), the ornate butterfly (*C. ornatissimus*), Meyer's butterfly (*C. meyeri*), and the forcepsfish (*Forcipiger flavissimus*).

Angelfish (Pomacanthidae):

The most commonly observed angelfish was the flame angel (*Centropyge loricula*) with unusually high densities of small individuals at sites along the west. Two angels of the genus Apolemichthys, which are often rare at the depths of our surveys, were frequently observed (Griffis' angel, *A. griffisi* and the gold-spotted angel, *A. xanthopunctatus*). Also common were large emperor angels (*Pomacanthus imperator*) and the lemonpeel angel (*C. flavissima*) which showed increased densities along the west side.

Damselfish (Pomacentridae):

Damselfish diversity was relatively low at all sites with only 11 observed species. By far the most abundant species was the fusilier damsel (*Lepidozygous tapeinosoma*), a planktivore that was observed in massive schools above and along reef edges mixed with the previously described Bartlett's anthias. Two species of chromis, the bicolor chromis (*C. margaritifer*) and Vanderbilt's chromis (*C. vanderbilti*), two species of Plectroglyphidodon (*P. dicki* and *P. johnstonianus*), and the golden gregory (*Stegastes aureus*) made up the bulk of the remaining damselfish biomass.

Wrasses (Labridae):

The wrasses were the most diverse of all families with 26 species observed. Initial phase bluehead wrasse (*Thalassoma amblycephalum*) were exceptionally abundant along the east side and were seen in large groups of tens to hundreds of individuals. There were exceptionally large individuals of several species including the clown coris (*Coris aygula*) and the barred thicklip (*Hemigymnus fasciatus*). Cleaner wrasses were quite common with *L. dimidiatus* and *L. rubrolabiatus* being about equally common.

Parrotfish (Scaridae):

Only six species of parrotfish were observed. The three most common were the bridled parrotfish (*Scarus frenatus*), the redlip parrot (*S. rubroviolaceus*), and the Pacific steephead parrot (*Chlororus microrhinos*). Individuals were quite large with several *C. microrhinos* individuals exceeding 60 cm in length.

Surgeonfish (Acanthuridae):

Two species dominated the surgeonfish fauna at all sites – whitecheek surgeonfish (*Acanthurus nigricans*) and spotted bristletooth (*Ctenochaetus marginatus*), but density was relatively low for all species. Also common was the longnose tang (*Zebrasoma rostratum*). Along drop-offs of the west side, the elongate surgeonfish (*A. mata*), a planktivore, was often observed in loose aggregations.

Rare or Absent Families:

Several families of reef fishes commonly observed in similar types of habitats were not encountered by the fish REA team at Jarvis. These include the lizardfishes (Synodontidae), fusiliers (Caesionidae), sweetlips (Haemuliade), and the sandperches (Pinguipedidae). The tow team did report one sighting of the yellowback fusilier (*Caesio teres*). Only one species of scorpionfish (Scorpaenidae), the spotted croucher (*Caracanthus maculatus*) was observed by the REA team.

Notes on Rare Species, Alternate Color-morphs, and Range Extensions

A damselfish, the yellowtail sergeant (*Abudefduf notatus*), was observed by both the fish and tow teams, which constitutes a considerable range extension for this species previously reported to occur no further east than New Britain.

Blue-lined triggerfish (*Xanthichthys caeruleolineatus*) were observed along the north, south, and west sides in depths as shallow as 10 m. This species is usually encountered at depths of 75-200 m.

Species with Uncertain Identifications

Several fish species have not been identifiable in the field. We have collected video and still photographic images for all of the unidentified species that will allow for positive identification upon return to Honolulu. Summarized here are brief descriptions of the questionable species.

Grouper:

Possibly a color morph of the blacktip grouper (*Epinephelus fasciatus*), individuals showed varying intensities of solid red coloration with either two small white saddles high on the dorsal region or 2-5 white vertical bars (*Epinephelus retouti*?).

Eel:

A uniformly dark charcoal moray eel with slightly elongated jaws was observed at a depth of 80 ft on the west side.

Anthias:

An anthias similar to Bartlett's anthias (*Pseudanthias bartlettorum*), but with a distinct, narrow red vertical mark on the side was observed at several locations, but was not abundant.

Fish collection at Jarvis

About 34 fish were collected for genetic analysis relative to the following list of species requested from Jarvis:

Species	Observed	Collected
Acanthurus Achilles	Present	3
Acanthurus nigricans	Common	10
Acanthurus achxnigr	Not Observed	
Acanthurus triostegus	Uncommon	
Ctenochaetus striatus	Common	1
Dascyllus auripinnis	Not Observed	
Mulloidichthys mimicus	Not Observed	
Mulloidichthys vanicolensis	Not Observed	
Paracirrhites arcatus	Common	3
Paracirrhites xanthus	Uncommon	1
Zebrasoma rostratum	Common	7
Zebrasoma scopes	Uncommon	
Bodianus prognathus	Present	1
Stegastes aureus	Common	2
Centropyge loricula	Abundant	6
Plectroglyphyididon johnstonianus	Abundant	
Chaetodon trifascialis	Not Observed	

2. Palmyra Atoll

From 29 March to 1 April 2004, the fish census team (Robert Schroeder, Craig Musburger, and Mark Readdie) surveyed 10 total stations around the atoll. Habitats included the exposed outer reef slope and an expansive reef terrace off the west side of the atoll. These stations all were resurveys ("monitoring") of sites established by CRED in February of 2002 or 2001. Quantitative belt transects (BLT), stationary point counts (SPC), and qualitative REA surveys (for species presence) were conducted at each of these sites, using the same methodology as in previous years and summarized above. This is the first time complete SPCs were conducted in the U.S. Line Islands. The benthic team (corals, algae, invertebrates) followed the fish team at most survey sites. The fish team conducted an additional collection dive the last day.

Our general impression (pending statistical confirmation) was that fish assemblages at Palmyra continued to be healthy, as was found in CRED's 2001 and 2002 cruise surveys. Large fish were common but not as abundant as at Jarvis. Sharks (mostly gray reef and white tips) were occasionally seen, but seemed to be slightly less common than 2 years ago.

The south side of the atoll was characterized by outer reef slope habitat. The west side of the atoll was characterized by an expansive reef shelf (40-60 ft deep) with good coral cover and habitat rugosity. No REA surveys were conducted along the north or east sides of the atoll due to 20+ kn winds from the NE, creating large seas and making diving conditions unworkable from the small inflatable boats. Underwater visibility averaged 70-80 ft at most sites. Water temperature was fairly consistent at ~82^{o}F.

Fish Family Summaries

The total number of coral reef fish species CRED documented in 2002 for Palmyra was 195. The total number of species we observed in 2004 was 209 (from 34 families), this time with three diver-observers (rather than only two), but one less station than in 2002. Following is a brief synopsis of some of the more abundant families.

Sharks (Carcharinidae, Rhincodontidae and Sphyrnidae):

Three species of shark were common at Palmyra. Reef blacktip (*Carcharinus melanopterus*) sharks were most common, with grey reef (*C. amblyrhynchos*) and reef whitetip sharks (*Triaenodon obesus*) also observed regularly. Most sharks ranged from 130 to 160 cm, and they seemed to be equally abundant around all surveyed areas (pending statistical confirmation).

Rays (Mobulidae and Myliobatidae):

Manta rays (*Manta birostris*) were observed commonly around Palmyra. Most individuals had wingspans between 6 and 10 feet with the occasional larger individual up to 14 ft. They were observed singly and in small groups of 3-5 individuals. They were especially abundant near the channel on the southwest side (site PAL-16p). A single spotted eagle ray (*Aetobatis narinari*) was observed by the REA team in the far southwest (site PAL-26). The tow team also observed a total of five eagle rays at Palmyra.

Soldier/Squirrelfish (Holocentridae):

Soldier/squirrelfish were not especially abundant at any site surveyed. Bigscale soldierfish (*Myripristis berndti*) and blue-lined squirrelfish (*Sargocentron tiere*) were most abundant, while tailspot squirrelfish (*S. caudimaculatum*) and sabre squirrelfish (*S. spiniferum*) were also observed.

Groupers/Anthias (Serranidae):

Palmyra hosted an extremely large number of grouper/anthias species (18). By far the most common grouper was the peacock grouper (*C. argus*) which was observed by the REA team at every survey site. Most individuals ranged from 15 to 35 cm. Also common was the flagtail grouper (*Cephalopholis urodeta*) and the camouflage grouper (*Epinephelus polyphekadion*).

Anthias were not nearly as abundant at Palmyra as they were at Jarvis. Bartlett's anthias (*Pseudanthias bartlettorum*) and the yellowtail anthias (*P. olivaceus*) were about equally abundant, but they were most often observed in small aggregations of 10-30 individuals.

Jacks (Carangidae):

Jacks were common at all sites. Giant trevally (*Caranx ignobilis*) up to 100 cm were often observed patrolling the reefs individually or in pairs. Bluefin trevally (*C. melampygus*) were observed at every REA site, and black jacks (*C. lugubris*) were also quite common. Exceptionally large (75+ cm) rainbow runners (*Elagatis bipinnulata*) were occasionally observed off steep drop-offs on the south side.

Snappers (Lutjanidae) and Emperors (Lethrinidae):

Snappers were very common at Palmyra. Twinspot snapper (*Lutjanus bohar*), humpback snapper (*L. gibbus*), smalltooth jobfish (*Aphareus furca*), and onespot snapper (*L. monostigma*) were observed at every REA site. Twinspot snapper generally ranged from 30 to 40 cm and were not as large as those seen at Jarvis. Humpback snappers were often observed in loose aggregations of up to 50 individuals.

The most common emperor was the bigeye emperor (*Monotaxis grandoculis*) with the yellowlip emperor (*Lethrinus xanthocheilus*) also observed. Several large (50 cm) longnose emperors (*L. olivaceus*) were observed at sites on the southeast (PAL-16, PAL-19, and PAL-26).

Butterflyfish (Chaetodontidae):

Seventeen species of butterflyfish were observed at Palmyra. Most common were the raccoon butterfly (*Chaetodon lunula*), the ornate butterfly (*C. ornatissimus*), oval butterfly (*C. lunulatus*), the chevron butterfly (*C. trifascialis*) and the forcepsfish (*Forcipiger flavissimus*).

Angelfish (Pomacanthidae):

The most commonly observed angelfish were the lemonpeel angel (*Centropyge flavissima*) and the flame angel (*C. loricula*), both of which were observed at nearly all sites surveyed. Emperor angels (*Pomacanthus imperator*) were also occasionally observed and one individual gold-spotted angel (*Apolemichthys xanthopunctatus*) was observed deep off the southeast (site PAL-25).

Damselfish (Pomacentridae):

Fifteen species of damselfish were observed by the REA team. Four species of chromis made up the bulk of the damselfish biomass (bicolor chromis [*Chromis margaritifer*], Vanderbilt's chromis [*C. vanderbilti*], midget chromis [*C. acares*], and black chromis [*C. xanthura*]). Two species of *Plectroglyphidodon* (*P. dicki* and *P. johnstonianus*), the golden gregory (*Stegastes aureus*) and the neon damsel (*Pomacentrus coelestis*) were also observed regularly.

Wrasses (Labridae):

Once again, the wrasses were the most diverse of all families with 39 species observed. Species that were observed at nearly every site included slingjaw wrasse (*Epibulus insidiator*), bird wrasse (Gomphosus varius), checkerboard wrasse (*Halichoeres hortulanus*), the cleaner wrasses (*Labroides bicolor*, *L. dimidiatus* and *L. rubrolabiatus*), sixline wrasse (*Pseudocheilinus hexataenia*), and eightline wrasse (*P. octotaenia*). Napoleon wrasse (*Cheilinus undulates*) were observed regularly with several individuals ranging up to 100 cm.

Parrotfish (Scaridae):

Thirteen species of parrotfish were observed at Palmyra. Most common were the bridled parrotfish (*Scarus frenatus*), the redlip parrot (*S. rubroviolaceus*), the bullethead parrot (*Chlororus sordidus*), and the Pacific steephead parrot (*C. microrhinos*). One exceptionally large aggregation of approximately 500 filament-fin parrots (*S. altipinnis*) was observed grazing at a site in the northwest (PAL-18).

Surgeonfish (Acanthuridae):

Three species of surgeonfish were most common: whitecheek surgeonfish (*Acanthurus nigricans*), striped bristletooth (*Ctenochaetus striatus*), and bluespotted bristletooth (*Ctenochaetus marginatus*). Yellowfin surgeonfish (*A. xanthopterus*) were also quite common, and individuals ranged up to 30 cm. Only one species of unicornfish was observed regularly - the orangespine unicorn (*Naso lituratus*). Occasional groups of blacktongue unicorns (*N. hexacanthus*) and bluespine unicorns (*N. unicornis*) were observed.

Fish collection at Palmyra

Sixty-eight fish were collected (by permit) for genetic analysis relative to the following list of species requested from Palmyra:

Species	Observed	Collected
Acanthurus triostegus	Present	21
Dascyllus auripinnis	Present	10
Mulloidichthys mimicus	Uncommon	0
Mulloidichthys vanicolensis	Uncommon	0
Paracirrhites arcatus	Common	8
Paracirrhites xanthus	Not Observed	0
Zebrasoma rostratum	Present	6
Zebrasoma scopes	Present	5
Bodianus prognathus	Present	0
Centropyge loricula	Abundant	9

Species	Observed	Collected
Plectroglyphyididon johnstonianus	Abundant	3
Thalassoma lutescens	Present	1
Chaetodon trifascialis	Common	5

3. Kingman Reef

From 2 to 4 April 2004, the fish census team (Robert Schroeder, Craig Musburger, and Mark Readdie) surveyed nine total stations around the atoll. Habitats included the exposed outer reef slope along the S, inner reef slope along the E and S arms, inner reef flat and patch reef slopes inside the atoll. These stations all were resurveys ("monitoring") of sites established by CRED in February of 2002 or 2001. Quantitative belt transects (BLT), stationary point counts (SPC), and qualitative REA surveys (for species presence) were conducted at each of these sites, using the same methodology as in previous years and summarized in the first report (for Jarvis). This is the first time complete SPCs were conducted in the U.S. Line Islands. The benthic team (corals, algae, invertebrates) followed the fish team at all survey sites.

Our subjective impression (pending statistical confirmation) was that fish assemblages generally remain healthy at Kingman, as found by previous CRED cruise surveys. However, overall fish density, for both small and especially large fish appeared lower than before, with the possible exception of assemblages along the outer reef slopes. An average of only about one or two sharks (mostly small gray reef and white tips) were seen during each dive, compared to about a dozen sharks observed on a typical REA dive 2 years ago. No maori wrasse (*Cheilinus undulatus*) or bumphead parrotfish (*Bolbometopon muricatum*) were observed by any dive team, consistent with previous years. Like Palmyra and Jarvis, Kingman is a USFWS wildlife refuge and levels of historical or recent fishing are unknown.

Benthic habitat was generally of high rugosity and dominated by live coral cover at all sites. Inner reef slope habitats had relatively more dead coral and rubble. No REA surveys were conducted along the outer NE side or deeper exposed NW side of the atoll due to 20+ kn winds from the NE and large seas. Underwater visibility averaged 80-90 ft at most sites. Water temperature was fairly consistent at ~82^{o}F.

Fish Family Summaries

The total number of coral reef fish species CRED documented in 2002 for Kingman was 149. In 2004, the fish REA team observed 165 species from 34 families at Kingman, this time with three fish REA diver-observers (rather than only two), and the same number of stations (9) as in 2002. An additional 22 species and one additional family were observed by tow team divers bringing the total number of observed species in 2004 to 187 and families to 35. Following is a brief synopsis of some of the more abundant families.

Sharks (Carcharinidae):

Sharks were less abundant and smaller (pending statistical confirmation) at Kingman than at either Jarvis or Palmyra. Again, three species of shark were most common: reef blacktip (*Carcharinus melanopterus*), grey reef (*C. amblyrhynchos*), and reef whitetip sharks (*Triaenodon obesus*). The reef whitetips appeared to be most common, though several dives included no shark sightings. One tiger shark (*Galeocerdo cuvier*) was observed by the tow team.

Rays (Mobulidae and Myliobatidae):

A single manta ray (*Manta birostris*) was observed by the REA team along the outside of the southern side of Kingman (site KIN-11). A single spotted eagle ray (*Aetobatis narinari*) was observed by the REA team in the southeast portion of the lagoon (site KIN-03).

Soldier/Squirrelfish (Holocentridae):

Soldier/squirrelfish were not especially abundant at any site surveyed. Sabre squirrelfish (*S. spiniferum*) were mostly sighted and were generally observed singly or in pairs. Bigscale soldierfish (*Myripristis berndti*), blue-lined squirrelfish (*Sargocentron tiere*), and blackfin squirrelfish (*Neoniphon opercularis*) were also observed.

Groupers/Anthias (Serranidae):

Groupers were not as abundant at Kingman compared to Palmyra or Jarvis. By far the most common grouper was the peacock grouper (*C. argus*) which was observed by the REA team at every survey site. Also relatively common were the flagtail grouper (*Cephalopholis urodeta*) and the camouflage grouper (*Epinephelus polyphekadion*).

Anthias were not nearly as abundant at Kingman as they were at Palmyra. The yellowtail anthias (*Pseudanthias olivaceus*) was the only species regularly observed, and usually they were seen in small groups of 10-20.

Jacks (Carangidae):

Six species of jacks were observed at Kingman. Most common were bluefin trevally (*Caranx melampygus*) and black jacks (*C. lugubris*) although jacks in general were again less abundant than at Palmyra or Jarvis.

Snappers (Lutjanidae):

Twinspot snapper (*Lutjanus bohar*) was the only obviously common large predators at Kingman. While most were smaller than those observed at Palmyra or Jarvis, they were observed at every survey site. Humpback snapper (*L. gibbus*) and smalltooth jobfish (*Aphareus furca*) were also relatively common. One individual of green jobfish (*Aprion virescens*) was seen in the lagoon.

Emperors (Lethrinidae):

The only species of emperor observed by the fish REA team was the bigeye emperor (*Monotaxis grandoculis*) which was observed at every REA site. The tow team also observed the longnose emperor (*Lethrinus olivaceus*).

Butterflyfish (Chaetodontidae):

Fifteen species of butterflyfish were observed at Kingman. Commonly observed species included the raccoon butterfly (*Chaetodon lunula*), the ornate butterfly (*C. ornatissimus*), the oval butterfly (*C. lunulatus*), the forcepsfish (*Forcipiger flavissimus*), and the chevron butterfly (*C. trifascialis*). One species, Thompson's butterfly (*Hemitaurichthys thompsoni*) was observed at Kingman which was not seen at Jarvis or Palmyra.

Angelfish (Pomacanthidae):

The most commonly observed angelfish was the lemonpeel angel (*Centropyge flavissima*) which was observed at all sites surveyed. The flame angel (*C. loricula*) was the only other angelfish observed by the fish REA team. Emperor angels (*Pomacanthus imperator*) and gold-spotted angels (*Apolemichthys xanthopunctatus*) were observed by the tow team.

Damselfish (Pomacentridae):

Thirteen species of damselfish were observed by the REA team. Three species of chromis made up the bulk of the damselfish biomass (bicolor chromis [*Chromis margaritifer*], midget chromis [*C. acares*], and black chromis [*C. xanthura*]). Jonhston's damsel (*Plectroglyphidodon johnstonianus*), the golden gregory (*Stegastes aureus*), and the neon damsel (*Pomacentrus coelestis*) were also observed regularly. Goldbelly dascyllus (*Dascyllus aurripinnis*) were also common.

Wrasses (Labridae):

Once again, the wrasses were the most diverse of all families with 34 species observed. Commonly observed species included axil-spot hogfish (*Bodianus axillaris*), bird wrasse (*Gomphosus varius*), checkerboard wrasse (*Halichoeres hortulanus*), the cleaner wrasses (*Labroides bicolor, L. dimidiatus* and *L. rubrolabiatus*), sixline wrasse (*Pseudocheilinus hexataenia*), and eightline wrasse (*P. octotaenia*). No napoleon wrasse (*Cheilinus undulatus*) was observed at Kingman by either the REA or tow teams.

Parrotfish (Scaridae):

Twelve species of parrotfish were observed at Kingman. Most common were the bridled parrotfish (*Scarus frenatus*), the redlip parrot (*S. rubroviolaceus*), and the Pacific steephead parrot (*C. microrhinos*). Parrotfish were not abundant at any REA site, and many individuals were juveniles or small adults. No bumphead parrotfish (*Bolbometopon muricatum*) were observed at Kingman by either the REA or tow teams.

Surgeonfish (Acanthuridae):

Whitecheek surgeonfish (*Acanthurus nigricans*) and striped bristletooth (*Ctenochaetus striatus*) were often the only species of surgeonfish observed along transects by the fish team. While a total of 24 species were observed by the REA and tow teams, these two species dominated the family.

Notes on Rare Species

Two gobies (*Gnatholepis cauerensis* and *Amblyeleotris fasciata*) were seen on the NE inner reef slope at Kingman, the only gobies seen in the U.S. Line Islands during this cruise. A few lizardfish (*Synodus* sp.) were also seen only at Kingman.

Fish collection at Kingman

About 55 fish specimens were collected (by permit) for genetic analysis relative to the following list of species requested from Kingman:

Species	Observed	Collected
Acanthurus triostegus	Uncommon	1
Dascyllus auripinnis	Common	10
Mulloidichthys mimicus	Uncommon	0
Mulloidichthys vanicolensis	Uncommon	1
Paracirrhites arcatus	Common	7
Paracirrhites xanthus	Not Observed	0
Zebrasoma rostratum	Present	7
Zebrasoma scopes	Present	4
Bodianus prognathus	Not observed	0
Centropyge loricula	Uncommon	0
Plectroglyphyididon johnstonianus	Abundant	13
Thalassoma lutescens	Common	7
Chaetodon trifascialis	Common	5

Appendix B: Benthic-Corals REA Team Activity Summary *(Jean Kenyon, James Maragos)*

A. Methods

Coral survey methodology used is the same previously used during the American Samoa phase of the 2004 Equatorial survey (OES 04-02). At each REA site, the first two 25-m transect lines previously laid out by the fish team were videotaped. Kenyon recorded the videotapes and will use them later to analyze percent cover data. The tapes also provide a permanent record of the condition of the benthos at each REA site. Both investigators shared in field collection of coral population and size distribution data. Each coral whose center fell within 1.0 meter along the first two transect lines were identified in situ to genus and assigned to one of 7 size classes based on the estimated length of their longest diameters; the seven size classes are: 1-5 cm, 6-10, 11-20, 21-40, 41-80, 81-160, and >160 cm. Moreover, both investigators endeavored to take digital photographs of coral species, including those within a broader area beyond the transect lines, to compile and document a more complete inventory of coral biodiversity at each REA site.

B. Results

1. Jarvis Island

On 26 and 27 March 2004, two investigators, Jean Kenyon of the CRED and Jim Maragos of the USFWS, served as the coral dive team, participating in reef studies off Jarvis Island National Wildlife Refuge in the Line Islands. Results reported in this summary are a compilation of field data collected by both investigators in 2004. Maragos accomplished coral surveys at Jarvis in March 2000, February 2001, and January 2002 as part of the NOAA ship *Townsend Cromwell* expeditions, affording the opportunity to assess changes in corals over time.

Additionally, Maragos resurveyed his two permanent monitoring sites at Jarvis Island and established one new permanent monitoring site, each 50 m in length. At each permanent site, a 50-meter surveyor's tape was laid out along each transect alignment marked with stainless steel stakes previously installed at 5-meter intervals. A 1-meter square quadrat was laid contiguously and photographed along the entire transect at 1-meter intervals for a total coverage of 50 m^2 per transect for two of the sites (7P, 11P). However, only the first 20 m^2 of the transect at site 4P could be surveyed before the dive ended. These data will be later analyzed for the same parameters as the REA coral census data: percent coral cover, size class distribution, frequency, mean diameter, generic diversity, etc. Keith Golden kindly assisted in the permanent transect surveys.

Sites were chosen in consultation with other members of the benthic and fish teams, using criteria including spatial dispersion and the presence of permanent transects. Six sites (JAR-1, -10, -8, -4P, -7, -11P) were surveyed by the coral team in 2004 (Fig. 1). All six were previously surveyed by Maragos in 2000 (JAR-1, -4P, -8), 2001 (JAR-4P, -7), or 2002 (JAR-4P, -7, -10, -11P). Comparison with earlier surveys reveal that 2004 coral populations have continued to increase in size and abundance at southern and

western facing seaward reefs (JAR-4P, -7, -11P) over the 4 years of surveys. However, corals have declined precipitously since 2002 at northern and eastern facing seaward reefs (JAR-1, -8, -10). For example, visually estimated percent coral cover dropped from 50% to 1-25% at the latter sites and species numbers have also dropped from 20-21 to 4-9 at the same sites. In contrast, percent coral cover has remained high or increased slightly and species richness has remained at about 20 species at the south and western sites (JAR-4P, 7, 11P). Most likely heavy wave action from one or more storms during the past 2 years are responsible for the declines. Many surviving corals also showed signs of recent injury.

Colonies belonging to 15 anthozoan genera were observed by Kenyon/Maragos and counted within belt transects during quantitative surveys (Table 1). Members of the genera *Pocillopora* and *Montipora* dominated the coral fauna in terms of number of colonies, with each genus contributing more than 20% of the total number of colonies. The next most prolific genera were *Pavona* and *Sinularia*, each comprising 9.9% of the total number of colonies, though the latter was predominantly located at a single site along the southwest coast (JAR-7). Visual estimates of percent live cnidarian cover ranged from 1% or less at each of two sites along the north or northeast exposure (JAR-8, -1, respectively) to 70% at a site on the southwest side of the island (JAR-7); visual estimates of percent cover await comparison with values derived from computer-assisted quantitative analysis of videotapes recorded along transect lines and with similar analyses of the photoquadrats at the permanent transect sites. A total of 1061 cnidarian colonies (of which 933 were scleractinians) were counted in situ within a total survey area of 600 m^2, for an average colony density of 1.8 cnidarian colonies/m^2. Density values at individual sites ranged from 0.6/m^2 at site JAR-1 on the northeast side to 2.58/m^2 at a site along the southwest side (JAR-7). Generic diversity values followed patterns similar to those for colony density, with the lowest generic diversity (3 genera) at JAR-1, and the highest generic diversity (13 genera) observed at JAR 7. Inspection of a histogram showing the size class distribution of cnidarian colonies counted and classified within belt transects (Fig.2) shows that the majority (52.9 %) of colonies occur in the 20-80-cm size class, while 43.8% of the colonies measure < 20 cm in maximum diameter. These values will serve as a benchmark to compare with earlier and future data at the same permanent sites and from future population counts and video surveys conducted at the same REA sites.

Including all surveys since 2000, a total of 48 species and 20 genera of stony corals and 2 additional species and genera of soft corals have now been reported from Jarvis Island, including *Goniastrea retiformis* as a new species and genus record for the island in 2004. These totals are substantially lower compared to the atolls and atoll-like reefs in the Line Islands (Tabuaeran A., Kiritimati A., Palmyra A., Kingman Reef) studied by Maragos during the past 3 decades. Jarvis is small and lacks the lagoon habitats of the other four. As such the reefs at Jarvis lack the variety and protection afforded by the others. The apparent storm damage reported by us in 2004 further corroborates the likely effect of increased wave exposure limiting coral diversity and abundance at Jarvis Island.

Table 1. Number of cnidarians (Classes Anthozoa and Hydrozoa) reported at the REA sites at Jarvis Island by Kenyon and Maragos during March 2004 surveys.

	Jarvis	
Genera	# of colonies	Percent of total
Acropora	1	0.1%
Copscinaraea	1	0.1%
Echinophyllia/Oxypora	0	0.0%
Favia	3	0.3%
Favites	10	0.9%
Fungia	29	2.7%
Hydnophora	0	0.0%
Leptoseris	8	0.8%
Millepora	16	1.5%
Montipora	212	**20.0%**
Pachyseris	0	0.0%
Pavona	105	9.9%
Pocillopora	535	**50.4%**
Porites	11	1.0%
Psammacora	9	0.8%
Sinularia/Lobophytum	105	9.9%
Stylaster	7	0.7%
Tubastrea/Balanophyllia	9	0.8%
Total # colonies:	1061	100%

Figure 1. Location of coral benthic survey sites at Jarvis Island, March 2004

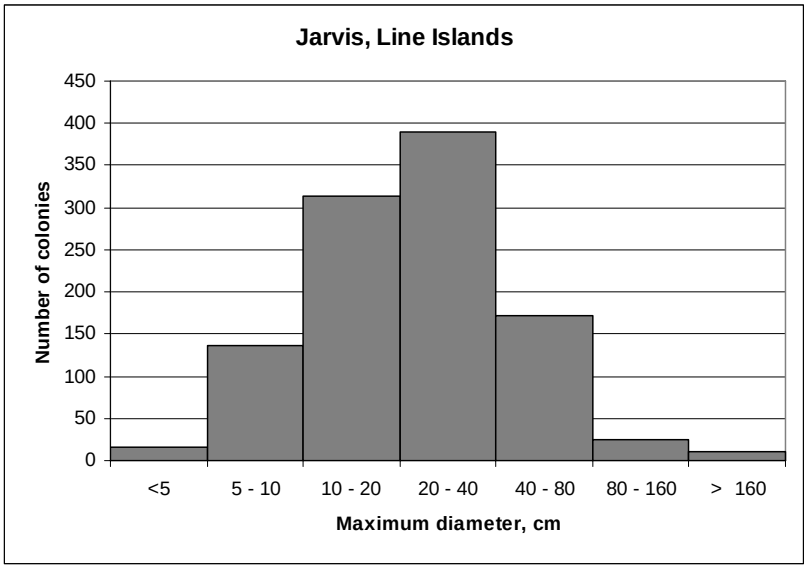

Figure 2. Size class distribution of 1061 cnidarian colonies tallied and classified by Kenyon and Maragos within belt transects at six sites at Jarvis, Line Islands, March 2004

2. Palmyra Atoll

Maragos accomplished six other coral surveys over the past 17 years at Palmyra. Starting in 2000, he established and resurveyed permanent transects at two sites (PAL-15P, -16P), and in 2004, he resurveyed site PAL-15P at the eastern reef pools, checked on the other site (16P) off the SW reef near the ship channel, and established a new permanent transect at site PAL-10P off the south reef. At each site a 50-m-long (PAL-10P) or 100-m-long (PAL-15P) surveyors tape was placed along the alignment of steel pins previously installed at 5- to 10-m intervals to mark the transect lines. A 1-meter-square quadrat frame was placed at each 1-meter interval along the line and photographed. The 50 quadrat photos for site PAL-10P and the 100 for site PAL-15P will be analyzed for the same coral parameters as for the REA sites: size distribution, frequency, generic diversity, percent coral cover, and extent of diseased and preyed-upon corals. Megan Moews kindly assisted in the permanent transect surveys.

Both Kenyon and Maragos collected small samples of select coral species on behalf of other investigators conducting studies on the population genetics of corals or their zooxanthellae. Additionally, Kenyon collected samples from eight species of acroporid corals at Palmyra and five acroporid species at Kingman to assess their sexual reproductive status and make inferences concerning their probable spawning time based on size of developing gonads. These samples for reproductive analyses will build upon data derived from similar collections made in 2002.

2004 Survey

Nine sites were surveyed by the coral team (Fig. 1). All nine sites had been visited by Maragos at least once during previous CRED surveys in 2000, 2001, or 2002. Sites were chosen in consultation with other members of the benthic and fish teams, using criteria including spatial dispersion and the presence of permanent transects. The first detailed surveys in 1987 by Maragos and Molina and Maragos in 1998 yielded over 130

species of stony corals, soft corals, and sea anemones, and the later surveys yielded another 35 species. These totals are substantially higher than the 80-90 species reported at the neighboring atolls of Tabuaeran (Maragos 1974) and Kiritimati (Maragos 1997) but comparable to the totals at neighboring Kingman Reef (Maragos 2000-2). These enhancements are likely attributed to many species of coral larvae transported to Palmyra and Kingman from the biodiversity-rich western Pacific via the eastward flowing Equatorial Countercurrent. Two new anthozoan generic records, *Scapophyllia* and *Cryptodendrum,* were added to the totals for Palmyra in 2004.

The 2004 surveys revealed that coral populations are continuing to recover from a likely mass coral bleaching event experienced at Palmyra between the 1987 and 1998 surveys. In 1987, the entire western reef terrace was completely blanketed in thickets of live staghorn and table *Acropora.* In 1998 these had been recently reduced to dead coral rubble, with only some recovery by rose corals (*Pocillopora*) and lobe corals (*Porites*). Since 1998, and especially during our 2004 surveys, lobe corals have become abundant and large off the western terrace. However, corals closer to the islands and lagoon (e.g., PAL-16) of the atoll have shown no noticeable recovery. Military construction during the World War II era at Palmyra blocked lagoon circulation and heated up lagoon waters that eventually discharged and mixed with ocean waters off the west side of the atoll. The elevated water temperatures may have contributed to the bleaching event and continue to discourage coral recovery on shallow nearshore reefs down-drift (west) of the lagoon.

In 2004 colonies belonging to 36 cnidarian genera were observed by Kenyon/Maragos and counted within belt transects during quantitative surveys (Table 1). Members of the genera *Pocillopora, Porites,* and *Pavona* dominated the coral fauna in terms of number of colonies, with each genus contributing more than 10% of the total number of colonies. Octocorals in the genera *Sarcophyton, Sinularia*, and *Lobophytum* were cumulatively responsible for 12% of the total number of cnidarian colonies. Visual estimates of percent live cnidarian cover ranged from 5% at a site just southeast of the dredged channel into the lagoon (PAL-16) to 70% at two sites on the western shelf (PAL-18 and PAL-26); of the nine sites visited, only two sites (PAL-16 and PAL-1) were assessed by one or both investigators as characterized by less than 50% live cnidarian cover. Visual estimates of percent cover await comparison with values derived from computer-assisted quantitative analysis of videotapes recorded along transect lines and from the photoquadrat data from two sites. However, videotransect data are unavailable for PAL-1 and PAL-18 due to the unfortunate loss of the housed video camera in swift current conditions during the last dive at Palmyra and insufficient remaining air/no-decompression time to search for and recover the equipment.

A total of 3701 cnidarians (of which 3120 were scleractinians) were counted within a total survey area of 750 m^2, for an average colony density of 4.93 cnidarian colonies/m^2. Density values at individual sites ranged from 2.9/m^2 at site PAL-16 just southeast of the dredged channel to 6.8/m^2 at a site along the southeast side (PAL-10). Generic diversity values followed patterns similar to those for colony density, with the lowest generic diversity (7 genera) at PAL-16, and the highest generic diversity (24 genera) observed at PAL-10. Inspection of a histogram showing the size class distribution of cnidarians counted and classified within belt transects (Fig.2) shows that the majority (62.8 %) of cnidarians occur in the 10-40-cm size class, with roughly similar proportions

of cnidarians measuring less than 10 or greater than 40 cm maximum diameter (21.1 % and 16.1%, respectively). These values will serve as a baseline to which data derived from surveys conducted in future years at the same sites can be compared.

The eastern reef pool site, PAL-15, termed "coral gardens," deserves special attention due to its unusual diversity and lush proliferation of *Acropora* corals. More than 80% of the total number of *Acropora* corals enumerated during the nine surveys occurred at this site. While this figure is partly a function of the shallow (4-5 ft.) depths at this site, a habitat in which *Acropora* are customarily abundant, visual scanning of shallow depths during safety stops at other dive sites did not reveal comparable coral communities elsewhere. Site PAL-15 is also updrift of any influence of the heated waters of the lagoon. Given the known susceptibility of *Acropora* to bleaching, *Acanthaster* predation, and disease, this site merits continued inclusion in all future monitoring efforts.

Table 1. Number of cnidarians (Classes Anthozoa and Hydrozoa) reported at the REA sites at Palmyra Atoll by Kenyon and Maragos during March/April 2004 surveys.

	Palmyra	
Genera	**# of colonies**	**Percent of total**
Acropora	133	3.6%
Astreopora	16	0.4%
Cryptodendrum	2	0.1%
Dendronephthya	15	0.4%
Echinophyllia	2	0.1%
Favia	206	5.6%
Favites	69	1.9%
Fungia	190	5.1%
Gardineroseris	1	0.0%
Goniastrea	8	0.2%
Halomitra	3	0.1%
Herpolitha	6	0.2%
Heteractis/Stichodactyla	2	0.1%
Hydnophora	73	2.0%
Leptastrea	7	0.2%
Leptoseris/Pachyseris	24	0.6%
Lobophyllia/Symphyllia	45	1.2%
Millepora	2	0.1%
Montastrea	37	1.0%
Montipora	175	4.7%
Palythoa	67	1.8%
Pavona	407	**11.0%**
Platygyra	51	1.4%
Pocillopora	903	**24.4%**
Porites	625	**16.9%**
Psammocora	16	0.4%
Sandalolitha	3	0.1%
Sarcophyton	218	5.9%
Scapophyllia	1	0.0%

	Palmyra	
Genera	**# of colonies**	**Percent of total**
Sinularia/Lobophytum	227	6.1%
Stylaster/Distichopora	31	0.8%
Stylocoeniella	1	0.0%
Stylophora	13	0.4%
Turbinaria	122	3.3%
Total # colonies:	**3701**	100%

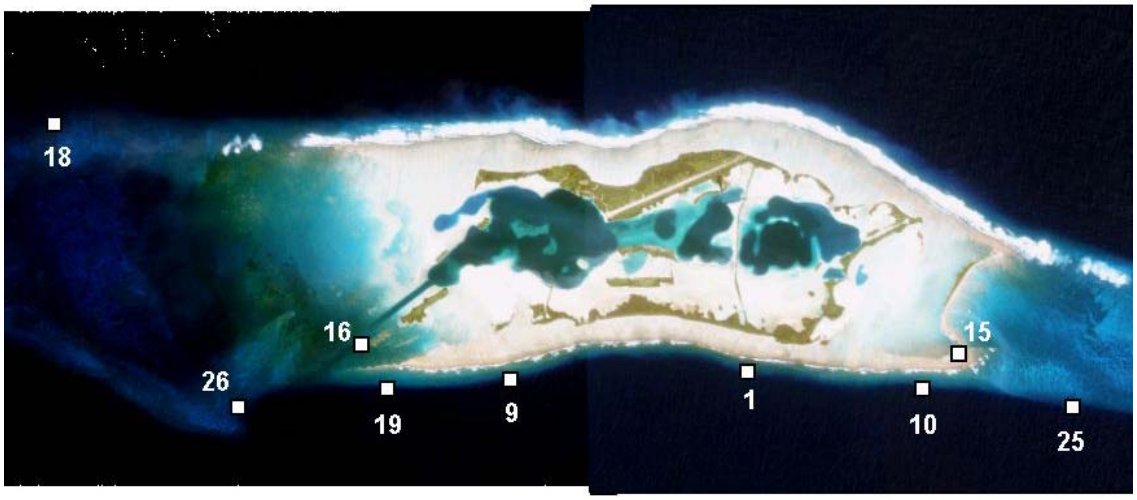

Figure 1. Location of coral benthic survey sites at Palmyra Atoll, March/April 2004.

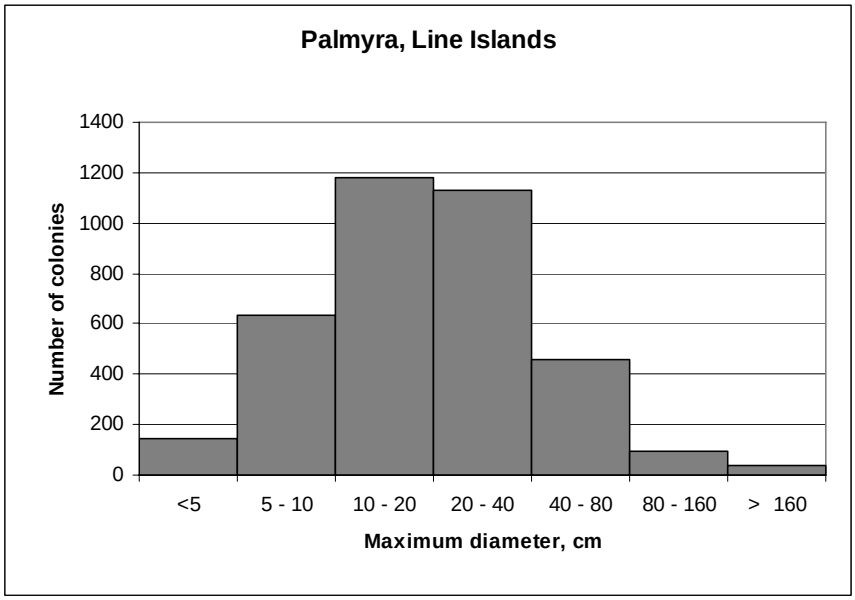

Figure 2. Size class distribution of 3701 cnidarians tallied and classified by Kenyon and Maragos within belt transects at nine sites at Palmyra Atoll, Line Islands, March/April 2004.

3. Kingman Reef

Nine sites were surveyed by the coral team (Fig. 3) in 2004. All nine sites had been visited by Maragos at least once during previous CRED surveys in 2000, 2001, or 2002. Sites were chosen in consultation with other members of the benthic and fish teams, using criteria including spatial dispersion and the presence of permanent transects. Two existing permanent transects (sites KIN-5P and KIN-16P) were resurveyed and a new permanent transect site (KIN-10) was established and surveyed during the 2004 visit.

Kingman is an atoll reef lacking vegetated land about 40 nmi NW of Palmyra. As with Palmyra, Kingman is often in the path of the eastward moving Equatorial Countercurrent that may transport the larvae of many coral species from the biodiversity-rich western Pacific. Totals of 157 species and 46 genera of corals and other anthozoans have now been reported from Kingman, second only to Palmyra in the Line Islands and nearly twice the number of species reported at other Line Island atolls (Kiritimati and Tabuaeran). One new generic record, *Scapophyllia*, was reported from Kingman in 2004. Compared to earlier observations, the coral communities at Kingman remain healthy and diverse, despite heavy predation from the crown-of-thorns seastar *Acanthaster.* Heavy predation on *Porites* observed in 2004 may be the consequence of the possible decline of *Acropora* due to earlier sea star predation. Eastern lagoon populations of *Porites* (KIN-5P) appear to be much larger compared to the initial observations in 2000.

Colonies belonging to 37 cnidarian genera were observed by Kenyon/Maragos and counted within belt transects during quantitative surveys (Table 2). Members of the genera *Fungia* and *Porites* dominated the coral fauna in terms of number of colonies, with each genus contributing 41.9% and 22.7% of the total number of colonies, respectively. The predominance of both genera is largely due to the location of all but two of the nine surveyed sites within the lagoon, where these two genera dominate. The proliferation of *Fungia* was especially high in the southeast corner of the lagoon (KIN-5 and KIN-16), where average densities of 23/m^2 were calculated. Members of the scleractinian genus *Favia* and alcyonacean genera *Sinularia* and *Lobophytum* were the next most abundant cnidarians, contributing 6.7% and 5.8% of the total number of coral colonies, respectively; the remaining 32 cnidarian genera cumulatively represented only 22.9% of colony abundance. Visual estimates of percent live cnidarian cover ranged from 10% at a northeast backreef site (KIN-8) to 75% at a southeast forereef site (KIN-11). Visual estimates of percent cover await comparison with values derived from computer-assisted quantitative analysis of videotapes recorded along transect lines and values from analysis of photoquadrat data from the three permanent transect sites.

A total of 5896 cnidarians (of which 5269 were scleractinians) were counted within a total survey area of 725 m^2, for an average density of 8.1 cnidarians/m^2. Density values at individual sites ranged from 3.46/m^2 at site KIN-13 on the southern forereef to 27.2/m^2 at KIN-16, the southeast lagoon site dominated by *Fungia*. Generic diversity was highest at the south forereef site (KIN-11), where 29 genera were recorded and ranged between 14 and 19 genera at all other sites. Inspection of a histogram showing the size class distribution of cnidarians counted and classified within belt transects (Fig.4) shows that the majority (62.5 %) of cnidarians occur in the 10-40-cm size class, and 29.9% of

cnidarians measure less than 10 cm in maximum diameter. Less than 10% of the cnidarians tallied at the sites surveyed achieved a maximum diameter greater than 40 cm. These values, as well as those from the past and present surveys at the permanent transects will serve as a baseline to which data derived from surveys conducted in future years at the same sites can be compared.

Table 1. Number of cnidarians (Classes Anthozoa and Hydrozoa) reported at the REA sites at Kingman Atoll by Kenyon and Maragos during April 2004 surveys.

	Kingman	
Genera	**# of colonies**	**Percent of total**
Acropora	63	1.1%
Alveopora	1	0.0%
Astreopora	45	0.8%
Cladiella	76	1.3%
Coscinaraea	1	0.0%
Echinophyllia	25	0.4%
Favia	395	6.7%
Favites	92	1.6%
Fungia	2470	**41.9%**
Gardineroseris	12	0.2%
Goniastrea	3	0.1%
Halomitra	1	0.0%
Heteractis	10	0.2%
Herpolitha	22	0.4%
Hydnophora	22	0.4%
Leptastrea	26	0.4%
Leptoseris	3	0.1%
Lobophyllia	7	0.1%
Merulina	3	0.1%
Millepora	1	0.0%
Montastrea	46	0.8%
Montipora	218	3.7%
Palythoa	5	0.1%
Pavona	66	1.1%
Platygyra	25	0.4%
Pocillopora	260	4.4%
Porites	1341	**22.7%**
Psammocora	29	0.5%
Rhodactis	3	0.1%
Sandalolitha	2	0.0%
Sarcophyton	190	3.2%
Scapophyllia	3	0.1%
Sinularia/Lobophytum	340	5.8%
Stylaster/Distichopora	2	0.0%
Stylophora	6	0.1%
Turbinaria	82	1.4%
Total # colonies:	**5896**	100%

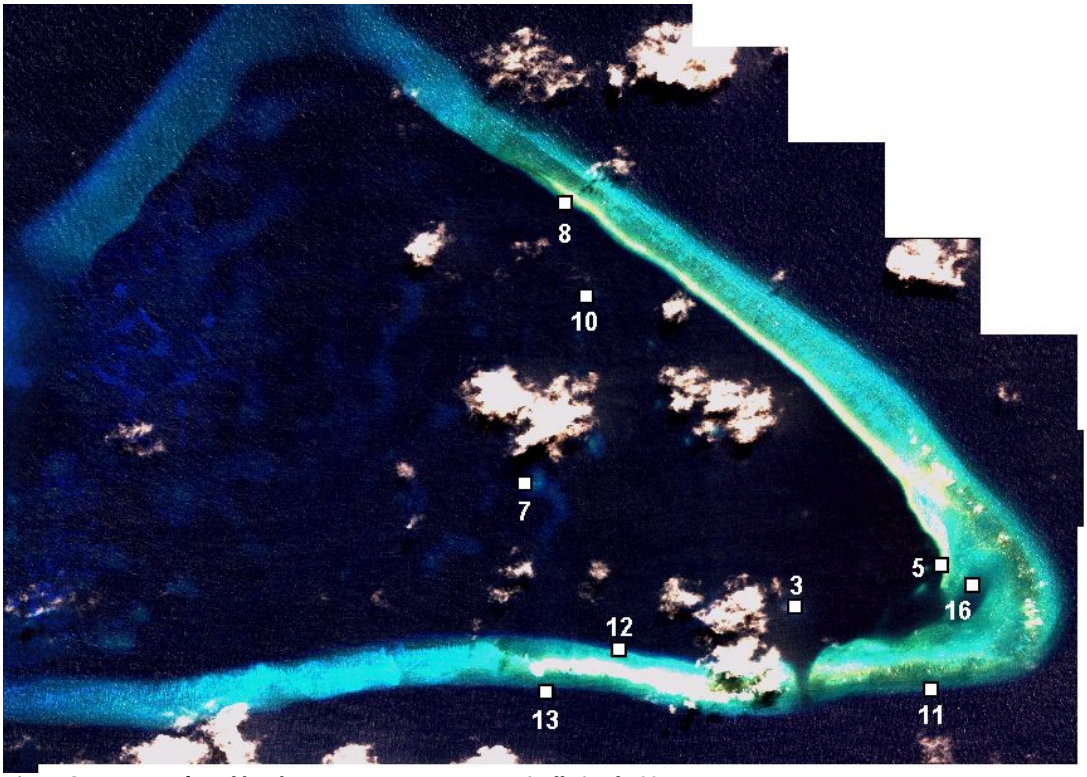

Figure 3. Location of coral benthic survey sites at Kingman Atoll, April 2004

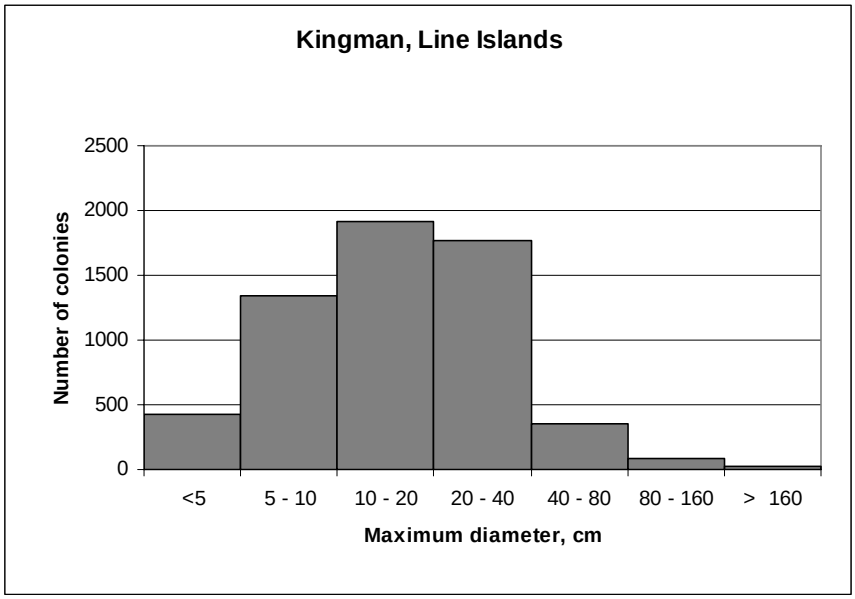

Figure 4. Size class distribution of 5896 cnidarians tallied and classified by Kenyon and Maragos within belt transects at nine sites at Kingman Atoll, Line Islands, April 2004.

Appendix C: Benthic-Algae REA Team Activity Summary *(Kim Page, Linda Preskitt)*

A. Methods

Used quantitative photoquadrat sampling methods to collect species composition and baseline abundance data of reef algae to compare with qualitative samples collected in previous years.

B. Results

1. Jarvis Island

Highlights

- There was a high abundance of an encrusting brown that is believed to be a *Lobophora* species.
- There was an unknown red alga that was very common at most of the sites visited.
- Red turfs were very common. It is believed that these are mixed assemblages of species and will need to be looked at more closely.
- No *Microdictyon* species were collected from Jarvis Island.

Site Descriptions

JAR- 10: This reef was on the SE side of Jarvis Island on a shelf at approximately 40 feet of water and was characterized by large fish/sharks and high surge and current. The benthos was characterized by *Pocillopora* and *Acropora* coral heads with a high abundance of crustose coralline and turf algae. In addition to these there was an unknown red alga that was flat, dichotomously branched and grew in prostrate mats. *Lobophora variegata*, *Halimeda* sp., *Dictyosphaeria versluysii*, and *Jania* were seen in the photoquadrats. In addition there was a red filamentous cyanophyte collected during the random swim.

JAR-1: This site was on the NE corner of Jarvis Island with depths and current similar to JAR-10, approximately 40 feet with high surge and current, however, less sharks. A school of manta rays (~10) were seen at this site. There was very little live coral at this site, and the dominant substrate was turf algae on large flat rocks as well as *Lobophora variegata*, and crustose coralline algae. Branched coralline algae, the unknown red from above, and *Halimeda* sp. were also seen in the photoquadrats at this site. What is believed to be a *Halymenia* sp. was found during the random swim.

JAR-8: This site was on the north side of Jarvis Island. This site was similar to site JAR-1; however, this reef was very sloped and the large flat rocks were replaced with "finger" (or "stag horn") coral rubble. However, turf algae, crustose coralline algae, and *Lobophora variegata* were the dominant substrate. The unknown red as well as *Dictyosphaeria versluysii*, *Halimeda* sp. were also seen in the photoquadrats.

JAR-4P: This site was on the south side of Jarvis Island and was characterized by high coral cover. Plate *Montiporids* and *Pocilloporids* were the dominant corals. Depths ranged from 35 to 45 ft with a gently sloping reef. Crustose coralline algae, turf algae, and *Lobophora* sp. were the dominant alga cover. Mats of *Valonia* sp. were also found toward the end of the second transect as well as a species of *Codium*. *Dictyota* sp. and *Halimeda* sp. were also seen in the photoquadrats. *Dictyosphaeria versluysii*, *Hypnea* sp., and a red filamentous cyanophyte were seen during the random swim.

JAR-7P: This site was on the west SW side of Jarvis and was characterized by the high abundance of soft coral. Turf, *Lobophora* sp., crustose coralline, and *Halimeda* were the dominant algae in the photoquadrats. *Caulerpa serrulata*, *Valonia* sp., *Dictyota* sp., *Dictyosphearia versluysii*, the red filamentous cyanophyte, as well as the unknown flattened branched rhodophyte seen at the other sites were collected during the random swim.

JAR-11P: This site was on the west NW side of Jarvis and was characterized by high relief. The transect line crossed a dredged channel and had a steep wall descending from 20 feet. The steepness required many of the photoquadrats to be taken at a vertical angle to parallel with the reef. There was a moderate surge. *Montiporids* were the dominant coral cover. Turf, crustose coralline algae, and *Lobophora* sp. were the dominant algae in the photoquadrats. *Halimeda* sp. and *Peyssonnelia* sp. were also found in the photoquadrats. The unknown red described above was collected during the random swim as well as *Caulerpa serrulata*, *Dictyosphaeria versluysii*, *Amphiroa* sp., and *Dictyota* species.

Table 1. Algae of Jarvis Island. Bold numbers indicate the number of photoquadrats in which an alga occurred; italicized numbers indicate the alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Standard deviation of island averages are given in parentheses. Asterisks indicate algae found during the random swim that did not occur in photoquadrats sampled.

	JAR10	**JAR1**	**JAR8**	**JAR4P**	**JAR7P**	**JAR11P**	**Island Averages**
Caulerpa					*	*	
Codium				**8.33** *5.00*			**1.39** **(3.40)** *5.00*
Dictyosphaeria	**16.67** *5.00*		**16.67** *4.50*	*	*	*	**5.56** **(8.61)** *4.75* *(0.35)*
Halimeda	**33.33** *3.25*	**25.00** *4.00*	**16.67** *4.00*	**25.00** *3.33*	**50.00** *3.33*	**16.67** *4.00*	**27.78** **(12.55)** *3.65* *(0.38)*
Valonia				**33.33** *3.50*	*		**5.56** **(13.61)** *3.50*
Amphiroa						*	
Halymenia		*					

	JAR10	JAR1	JAR8	JAR4P	JAR7P	JAR11P	Island Averages
Hypnea				*			
Peyssonnelia					**8.33** *2.00*	**8.33** *4.00*	**2.78** **(4.30)** *3.00* *(1.41)*
branched upright coralline	**58.33** *3.14*	**16.67** *3.50*					**12.50** **(23.42)** *3.32* *(0.25)*
crustose coralline	**100.00** *1.67*	**91.67** *2.82*	**100.00** *1.58*	**91.67** *1.73*	**83.33** *1.70*	**83.33** *1.70*	**91.67** **(7.45)** *1.87* *(0.47)*
Dictyota				**33.33** *4.25*	*	*	**5.56** **(13.61)** *4.25*
Lobophora	**33.33** *4.50*	**91.67** *2.00*	**100.00** *2.58*	**50.00** *3.00*	**75.00** *2.22*	**66.67** *2.88*	**69.44** **(25.09)** *2.86* *(0.89)*
Blue-green	*			*	*		
Turf	**100.00** *1.33*	**100.00** *1.08*	**100.00** *1.83*	**100.00** *1.50*	**66.67** *2.00*	**100.00** *1.33*	**94.44** **(13.61)** *1.51* *(0.34)*

2. Palmyra Atoll

Highlights

- There was a high abundance of multiple species of *Halimeda*.
- *Dictyosphaeria cavernosa* was commonly reported from sites at Palmyra Atoll. However, it was not seen at any other equatorial island visited.
- Red turfs were very common. It is believed that these are mixed assemblages of species and will need to be looked at more closely.
- *Microdictyon* sp. was not seen or collected from Palmyra.

Site Descriptions

PAL10, 9, 19, 25, 1: These sites were on the south forereef of Palmyra Atoll. The reefs were gently sloping and characterized by high coral diversity and high abundance of soft corals and *Halimeda* spp. Depths ranged from 40 to 46 feet. Along with *Halimeda* spp., turf algae, crustose coralline algae, *Dictyosphaeria versluysii*, *D. cavernosa*, *Dictyosphaeria* sp., *Avrainvillea amadelpha*, *Valonia* sp., a diminutive species of *Dasya* (classified as turf in the photoquadrat data) and an encrusting brown were seen in the photoquadrats. During the random swim, *Caulerpa serrulata f. spiralis*, *C. cupressoides*, a red filamentous cyanophyte, and an unknown red blade were collected.

PAL 16P: This was a lagoonal reef on the SW side of Palmyra Atoll on the south side of the channel. The depth ranged from 10 to 20 feet deep. The reef was mostly dead coral covered in the unknown orange crust (possibly *Lobophora* sp.), crustose coralline algae, turf algae, and *Galaxaura filamentosa*. In addition to these algae, *Halimeda* sp., *Dictyosphaeria versluysii*, *Caulerpa serrulata*, and a bulbous cyanophyte (possibly *Schizothrix* sp.) were seen in the photoquadrats.

PAL 26: This site was on the SW side of the Palmyra Atoll outside (west) of the channel. The reef was located on the western terrace of Palmyra with depths ranging from 45 to 55. The reef was dominated by plates of *Porites* sp. with high coral cover and diversity. Turf algae, crustose coralline algae, *Halimeda* spp., *Neomeris* sp., *Avrainvillea amadelpha*, and the unknown orange crust were seen in the photoquadrats. During the random swim, *Dictyosphaeria versluysii*, *D. cavernosa*, and *Caulerpa cupressoides* were seen.

PAL 15P: This site is in a protected lagoon called the "coral gardens" on the southeast side of Palmyra. The lagoon is very shallow with depths ranging from 1 to 15 feet. The reef was characterized by very high coral cover and diversity. The algal community seen in the photoquadrats was represented by crustose corallines, turf algae, *Halimeda* spp., branched corallines, *Avrainvillea amadelpha*, *Dictyosphaeria cavernosa*, *Caulerpa serrulata*, and a cyanophyte. The random swim yielded *Turbinaria* sp., more *Halimeda* sp., and an unknown red blade.

PAL 11: This site was on the western reef terrace of Palmyra Atoll in approximately 40 feet. This site had very heavy algal cover yet low diversity, with species from *Chlorophyta* dominating the macroalgal community. The most common algae were *Dictyosphaeria cavernosa*, *Halimeda* spp., an unknown orange crust, and crustose corallines. *Dictyosphaeria versluysii*, red turfs, and numerous species of *Halimeda* were collected during the random swim.

PAL 18: This site was located on the northwest corner of Palmyra Atoll in an area known for higher currents and winds. Transects were located on a forereef at approximately 65 ft. with a current of around 2 knots. The heavy current at that depth made photoquadrats too demanding, so a visual assessment was done. In the visual assessment, crustose corallines were the most abundant algal form, followed by turf algae, orange crustose algae, and *Halimeda* species. *Dictyosphaeria cavernosa*, *D. versluysii*, *Caulerpa cupressoides*, *Avrainvillea amadelpha* and red filamentous turfs were also collected during a random swim.

Table 1. Algae of Palmyra Atoll. Bold numbers indicate the number of photoquadrats in which an alga occurred; italicized numbers indicate the alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Standard deviations of island averages are given in parentheses. Asterisks indicate algae found during the random swim that did not occur in photoquadrats sampled.

	PAL 10	**PAL 9**	**PAL 19**	**PAL 16P**	**PAL 26**	**PAL 25**	**PAL 15P**	**PAL 1**	**Island Averages**
Avrainvillea	**8.33** *5.00*	**16.67** *5.50*	**8.33** *5.00*	**0.00**	**16.67** *4.50*	**0.00**	**41.67** *3.40*	* **0.00**	**11.46** **(14.04)** *4.68* *(0.80)*
Caulerpa	* **0.00**	* **0.00**	* **0.00**	**8.33** *6.00*	* **0.00**	* **0.00**	**16.67** *4.00*	**0.00**	**3.13** **(6.20)** *5.00* *(1.41)*
Dictyosphaeria	**41.67** *4.20*	**33.33** *3.50*	**8.33** *5.00*	**16.67** *5.50*	* **0.00**	**41.67** *3.00*	**66.67** *3.13*	**0.00**	**26.04** **(23.75)** *4.05* *(1.03)*
Halimeda	**83.33** *2.90*	**91.67** *2.73*	**83.33** *3.30*	**91.67** *3.73*	**75.00** *3.33*	**25.00** *2.00*	* **33.33** *2.50*	**83.33** *2.10*	**70.83** **(26.35)** *2.82* *(0.61)*
Neomeris	**0.00**	**0.00**	**0.00**	**0.00**	**8.33** *4.00*	**0.00**	**0.00**	**0.00**	**1.04** **(2.95)** *4.00*
Valonia	* **0.00**	**8.33** *5.00*	**0.00**	**0.00**	**0.00**	**8.33** *4.00*	**0.00**	**8.33** *5.00*	**3.13** **(4.31)** *4.67* *(0.58)*
Galaxaura	**0.00**	**0.00**	**0.00**	**100.00** *3.58*	**0.00**	**0.00**	**0.00**	**0.00**	**12.50** **(35.36)** *3.58*
Peyssonnelia	**16.67** *5.00*	**8.33** *4.00*	**0.00**	**0.00**	**8.33** *3.00*	**8.33** *3.00*	**0.00**	**0.00**	**5.21** **(6.20)** *3.75* *(0.96)*
branched upright coralline	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**8.33** *3.00*	**0.00**	**1.04** **(2.95)** *3.00*
crustose coralline	**91.67** *1.55*	**100.00** *1.67*	**100.00** *1.83*	**100.00** *2.25*	**100.00** *1.50*	**83.33** *1.60*	**75.00** *1.56*	**100.00** *1.67*	**93.75** **(9.71)** *1.70* *(0.24)*
Dictyota	**0.00**	**0.00**	**0.00**	* **0.00**	**0.00**	**0.00**	**0.00**	**0.00**	*

	PAL 10	PAL 9	PAL 19	PAL 16P	PAL 26	PAL 25	PAL 15P	PAL 1	Island Averages
orange crust	**75.00** *3.22*	**100.00** *3.50*	**91.67** *2.36*	**83.33** *2.10*	**50.00** *2.67*	**25.00** *3.33*	**8.33** *4.00*	**91.67** *2.73*	**65.63** **(34.05)** *2.99* *(0.63)*
Turbinaria	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	* **0.00**	**0.00**	*
Blue-green	* **0.00**	**0.00**	**8.33** *4.00*	**25.00** *5.00*	**0.00**	**0.00**	**8.33** *4.00*	**0.00**	**5.21** **(8.84)** *4.33* *(0.58)*
Turf	**100.00** *2.17*	**91.67** *2.45*	**91.67** *2.45*	**100.00** *3.08*	**91.67** *1.73*	**100.00** *1.67*	**91.67** *1.82*	**91.67** *3.09*	**94.79** **(4.31)** *2.31* *(0.57)*

3. Kingman Reef

Highlights

- Multiple species of *Halimeda* were the most abundant forms of frondose algae.
- Crustose corallines and various assemblages of turf algae were common.
- *Microdictyon* sp. was present at many sites surveyed.
- *Avrainvillea amadelpha* was collected at every site.
- *Neomeris* sp. appeared to be more prevalent at Kingman Atoll than Palmyra or Jarvis.

Site Descriptions

KIN 11: This site was a forereef on the southeast side of Kingman Atoll. Depths ranged from 40 to 55 feet on a gentle slope. There was high coral cover and diversity with a high abundance of soft corals. There was good visibility and little current. In the photoquadrats, *Halimeda* spp., turf algae, crustose corallines, *Dictyosphaeria versluysii*, *Microdictyon* sp., *cyanophytes*, orange crustose, *Neomeris* sp., *Peyssonnelia* sp., and *Valonia* sp. were noted and collected. During the random swim *Dictyosphaeria cavernosa*, *Avrainvillea amadelpha*, and *Caulerpa cupressoides* were seen.

KIN 13: This site was a forereef on the south side of the atoll near a sand island. This was a gently sloping reef similar to KIN 11 but with more turf and crustose coralline covered rubble. In addition to these, *Halimeda* spp., orange crustose, *Peyssonnelia* sp., *Ventricaria* sp., *Dictyosphaeria versluysii*, *Neomeris* sp., *Microdictyon* sp., a red filamentous *cyanophyte*, and *Avrainvillea amadelpha* were seen in the photoquadrats.

KIN 3: This site was a patch reef inside the channel on the southeast corner. There was large Porites heads and numerous live and dead *Fungia* sp. as well as a high abundance

of giant clams. There was also a high abundance of other invertebrates, i.e. anemones, sea cucumbers, and sea urchins. The green alga *Neomeris* sp. was very abundant at this site. In addition to *Neomeris* sp. turf algae, crustose coralline algae, *Halimeda* spp., *Microdictyon* sp., orange crustose, and *Caulerpa serrulata* were seen in the photoquadrats. During the random swim, *Avrainvillea amadelpha* and additional *Halimeda* species were collected.

KIN5P: This site was on a reticulated patch reef inside the lagoon on the southeast side of Kingman Atoll. Survey depths ranged from 38 to 48 feet. However, the reef sloped from very shallow (~1 foot) to the lagoon bottom. The site was dominated by *Fungia* spp., *Porites* spp., and giant clams. There was also an unusually high abundance of *Acanthaster planci* (crown of thorns). Algal species collected from photoquadrats included, *Halimeda* spp., turf algae, *Microdictyon* sp., *Neomeris* sp., crustose coralline, *Peyssonnelia* sp., orange crustose, and cyanophytes. During the random swim, a small red creeping macrophyte was collected as well as *Avrainvillea amadelpha*.

KIN 16P: This site was on a 20-foot deep flat back reef inside the lagoon on the southeast side of Kingman Atoll. This site was similar in composition to KIN 5P with a dominance of *Fungia* spp., *Porites* sp., and giant clams. Algae found in the photoquadrats included various turf algae, crustose coralline algae, branched coralline algae, *Microdictyon* sp., *Neomeris* sp., *Dictyosphaeria versluysii*, and orange crustose. During the random swim, *Avrainvillea amadelpha* and *cyanophytes* were also found.

KIN 12: This site was a sloping back reef on the south side of the Kingman Atoll near a small sand and rubble island. The survey depth ranged from 35 to 47 feet and was characterized by the abundance of *Porites* sp., *Fungia* spp., and sea urchins, with giant clams increasing in abundance farther up the slope. There also seemed to be a higher amount of sediment than at previous sites. Turf algae, *Halimeda* sp., crustose coralline algae, cyanophytes, *Avrainvillea amadelpha*, and *Neomeris* sp., were seen in the photoquadrats area. During the random swim, *Caulerpa serrulata*, *C. cupressoides*, *Bryopsis* sp., and *Valonia* sp. were collected.

KIN 19: This site was a shallow backreef directly adjacent to the sand island on the south side of Kingman Atoll. The area had primarily rubble and crustose coralline algae with high sedimentation. *Liagora* sp. was very abundant, covering large areas in the shallow sandy regions. Also collected were two species of *Halimeda*. No quantitative data was collected.

KIN 8: This site was a sloping inner backreef on the northeast side of Kingman Atoll. Transects were located at approximately at 50 feet with survey depths ranging from 35 to 50 feet. This site was characterized by high sediment and by the dominance of *Porites* sp. and *Fungia* species. There was also a high abundance of *Acanthaster planci*. Turf algae and a large, leathery *Halimeda* were the dominant algal forms. In addition to these, crustose coralline algae, *Halimeda* spp., *Neomeris* sp., *Caulerpa cupressoides*, *Microdictyon* sp., *Dictyosphaeria versluysii*, branched corallines, and cyanophytes were seen in the photoquadrats.

KIN10: This site was a patch reef slope on the northeast side of Kingman Atoll. The survey depth ranged from 35 to 50 feet. This site was dominated by *Porites* sp. and *Fungia* sp. There was also a high occurrence of anemones. Crustose coralline and turf algae were the dominant algae in the photoquadrats. In addition, *Microdicyton* sp., *Halimeda* spp., orange crustose, branching corallines, *Jania* sp., *Peyssonnelia* sp., and *Dictyosphaeria versluysii* were also found in the photoquadrats. During the random swim, *Avrainvillea amadelpha, Caulerpa cupressoides,* and red turfs were collected.

KIN 7: This site was very similar to KIN10, but was located on a patch reef in the center of the lagoon. *Porites* sp. was the dominant coral with a high abundance of *Fungia* sp., as well as urchins and giant clams. There were not as many anemones at this site. Turf algae, crustose corallines, *Halimeda* sp., *Microdictyon* sp., *Neomeris* sp., branched corallines, *Valonia* sp., *cyanophytes,* and *Jania* sp. were collected in the photoquadrat areas. During the random swim *Caulerpa cupressoides, Avrainvillea amadelpha* and an unknown small red blade were found.

Table 1: Algae of Kingman Atoll. Bold numbers indicate the number of photoquadrats in which an alga occurred; italicized numbers indicate the alga's relative abundance (rank) in relation to other algae occurring in the same photoquadrat. Standard deviations of island averages are given in parentheses. Asterisks indicate algae found during the random swim that did not occur in photoquadrats sampled.

	KIN 11	**KIN 13**	**KIN 3**	**KIN 5P**	**KIN 16P**	**KIN 12**	**KIN 8**	**KIN 10**	**KIN 7**	**Island Averages**
Avrainvillea	* **0.00**	**8.33** *6.00*	* **0.00**	* **0.00**	* **0.00**	**58.33** *4.14*	**16.67** *4.50*	* **0.00**	* **0.00**	**9.26 (19.30)** *4.88 (0.99)*
Bryopsis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	* **0.00**	**0.00**	**0.00**	**0.00**	*
Caulerpa	**8.33** *3.00*	**8.33** *5.00*	**8.33** *5.00*	**0.00**	**0.00**	* **0.00**	**8.33** *4.00*	* **0.00**	* **0.00**	**3.70 (4.39)** *4.25 (0.96)*
Dictyosphaeria	**16.67** *5.00*	**16.67** *5.50*	**0.00**	**0.00**	**33.33** *4.50*	**0.00**	**16.67** *5.00*	**0.00**	**0.00**	**9.26 (12.11)** *5.00 (0.41)*
Halimeda	**75.00** *2.00*	**75.00** *3.44*	**66.67** *3.25*	**83.33** *2.30*	**0.00**	**83.33** *2.50*	**83.33** *2.80*	**75.00** *2.78*	**100.00** *2.67*	**71.30 (28.29)** *2.72 (0.47)*
Microdictyon	**41.67** *5.00*	**0.00**	**25.00** *3.33*	**83.33** *3.40*	**50.00** *4.50*	**0.00**	**25.00** *3.33*	**66.67** *4.50*	**16.67** *4.00*	**34.26 (28.70)** *4.01 (0.68)*

	KIN 11	KIN 13	KIN 3	KIN 5P	KIN 16P	KIN 12	KIN 8	KIN 10	KIN 7	Island Averages
Neomeris	**8.33** *5.00*	**16.67** *5.00*	**75.00** *3.44*	**41.67** *3.60*	**41.67** *4.20*	**16.67** *4.50*	**25.00** *4.67*	**0.00**	**41.67** *4.60*	**29.63 (22.86)** *4.38 (0.59)*
Valonia	**16.67** *5.00*	**16.67** *4.00*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**16.67** *4.00*	**5.56 (8.33)** *4.33 (0.58)*
Ventricaria	**0.00**	**8.33** *7.00*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.93 (2.78)** *7.00*
Jania	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**25.00** *5.67*	**8.33** *6.00*	**3.70 (8.45)** *5.83 (0.24)*
Peyssonnelia	**50.00** *2.83*	**16.67** *3.50*	**0.00**	**16.67** *4.50*	**0.00**	**0.00**	**0.00**	**16.67** *4.50*	**0.00**	**11.11 (16.67)** *3.83 (0.82)*
branched upright coralline	**0.00**	**0.00**	**0.00**	**0.00**	**41.67** *2.60*	**0.00**	**25.00** *3.33*	**66.67** *2.88*	**16.67** *4.50*	**16.67 (23.94)** *3.33 (0.84)*
crustose coralline	**75.00** *2.11*	**100.00** *1.92*	**91.67** *2.09*	**50.00** *2.83*	**83.33** *2.30*	**100.00** *2.42*	**50.00** *2.17*	**100.00** *1.58*	**100.00** *1.92*	**83.33 (20.83)** *2.15 (0.35)*
orange crust	**16.67** *2.50*	**58.33** *3.29*	**8.33** *4.00*	**8.33** *5.00*	**8.33** *5.00*	**0.00**	**0.00**	**25.00** *4.33*	**0.00**	**13.89 (18.63)** *4.02 (0.99)*
Blue-green	**8.33** *4.00*	**25.00** *4.00*	**0.00**	**8.33** *4.00*	* **0.00**	**8.33** *4.00*	**25.00** *3.67*	**0.00**	**16.67** *4.00*	**10.19 (10.02)** *3.94 (0.14)*
turf	**100.00** *1.92*	**100.00** *1.33*	**100.00** *1.08*	**100.00** *1.00*	**100.00** *1.00*	**100.00** *1.00*	**100.00** *1.08*	**100.00** *2.17*	**75.00** *1.33*	**97.22 (8.33)** *1.32 (0.43)*

Appendix D: Benthic-Invertebrates REA Team Activity Summary *(Scott Godwin)*

A. Methods

The purpose of the activities for OES-04-04 was to select sites surveyed during previous rapid ecological assessments for long-term monitoring. Selection of sites was based on their year-round accessibility and their representation of the habitats present at each site. Surveys focusing on marine invertebrates other than corals were performed in conjunction with surveys of coral and macroalgae, collectively termed the benthic survey. This benthic survey was conducted collaboratively with fish surveys. This report will cover the non-coral invertebrates encountered and from this point forward any mention of marine invertebrates refers to this particular group.

Quantitative counts for specific target marine invertebrates were done along two separate 2X25 meter belt transects. This was followed by two 10X25 meter quadrat surveys accomplished by swimming a zigzag search pattern. A quadrat survey was conducted in conjunction with both 2X25 transects, which were used as the reference line for the long axis. The counts from these two 10X25 quadrats were combined into a single 10X50 meter area.

Based on data from previous rapid ecological assessments, a group of target species was chosen for quantitative counts. The species in this list were chosen because they have been shown to be common components of the reef habitats of the central and southern Pacific, and they are species that are generally visible (i.e., non-cryptic) and easily enumerated during the course of a single 50-60-minute scuba survey.

These target species were:

CNIDARIA
Zoanthids – rubber corals
Actiniaria - Anemones

ECHINODERMS
Echinoids – sea urchins
Holothuroids – sea cucumbers
Ophiuroids – brittle stars (generally cryptic but are visible in some cases)

MOLLUSCA
Bivalves – ark shells, spondylid oysters, pearl oysters
Nudibranchs – sea slugs
Gastropods – snails
Cephalopods – Octopus

CRUSTACEA
hermit crabs, lobsters, large crabs, and shrimp

Collections of species that cannot be identified in the field, and samples of coral rubble were brought back to the laboratory on the research vessel. The cryptic organisms

found in the rubble are picked out and preserved, and the sand samples are dried and bagged so they can be examined for micro-mollusks at a later date.

The marine invertebrate species recorded and identified during the course of the field operations for OES-04-04 represent the non-cryptic fauna of the reef habitat and should not be considered the only species present at each site. There is an abundance of other organisms, both cryptic and non-cryptic, that dwells in these habitats that are not included in the rapid assessment scheme, which will be included in a final species inventory at a later date.

B. Results

1. Jarvis Island

Site Narratives

JAR-10

SE edge of and extensive reef terrace on the eastern side of the island. Heavy current and swell prevented a complete survey of the site. The cursory survey completed revealed a diverse and abundant macroinvertebrate community composed of gastropods, hermit crabs, other mobile crustacea, and a variety of sessile fauna. The sessile fauna was made up of hydrozoans, bryozoans, and barnacles.

JAR-01, 08

No marine invertebrate survey done.

JAR-4P

Central south shore. *Montipora* and *Pocillopora* dominated community with abundant crustacean and gastropod fauna. The dominant macroinvertebrate species were hermit crabs of two genus, *Calcinus* and *Dardanus*, cone shell gastropods and the sea urchin *Echinothrix calamaris*. Octopus were common throughout the habitat.

JAR-7P

SW corner of the island. Reef structure composed of buttresses and channels with extensive sand expanse at the base. The habitat was dominated by the soft coral *Sinularia* and the hard coral *Pocillopora*. The habitat was dominated by *Linckia* starfish and *Echinothrix calamaris* sea urchins. A single *Tridacnid maxima* giant clam was recorded on the upper portion of a buttress.

JAR-11P

Central west shore. *Montipora* and *Pocillopora* dominated community by the presence of echinoderms, gastropods, and crustaceans. Two species of starfish, *Linckia multifora* and *Linckia guildingi* were extremely abundant throughout the habitat. Also abundant were the sea urchins *Echinothrix* and *Diadema*. Octopus were common throughout the habitat as well.

General Impressions

All sites surveyed demonstrated abundant and diverse populations of macroinvertebrates. Site 4P has likely experienced a bleaching event in the past and is in a state of recovery, which was noted in a 2002 survey. This site is dominated by the pioneering species of coral and the associated macroinvertebrate species that have developed in conjunction with this recovery. All sites had impressive diversity and abundance and have remained at a healthy state since last surveyed 2 years ago. The unique set of oceanographic conditions at Jarvis Island appear to allow more than adequate levels of larval recruitment and primary productivity to support the diverse and abundant assemblages of mobile and sessile marine invertebrates. These conditions give Jarvis Island a noticeable edge in species abundance and diversity from the standpoint of marine macroinvertebrates.

2. Palmyra Atoll

Site Narratives

PAL-10

SE side. Gently sloping forereef with high coral diversity. There was a great abundance of soft corals composed mainly of *Sinularia*, *Sarcophyton,* and *Lobophyton*. An unknown species of soft coral that appeared to be from the genus *Dendonephtya* was recorded commonly at the site. The hydrozoa *Stylaster* was common at the site, as were the hydroids *Gymangium* and *Aglaophenia*. The gastropod *Ovula ovum*, which feeds exclusively on *Sinularia* and *Sarcophyton,* was recorded at the site. A starfish from the genus *Fromia* was recorded but was rare.

PAL-09

S side. Habitat similar to PAL-10 with high coral diversity and the same complement of species. One new record for this site was the anemone *Cryptodendrum,* which was rare.

PAL-25

SE side. Extensive reef with high coral abundance and diversity. The dominant macroinvertebrates were the hydrozoa *Gymangium*, *Stylaster,* and *Distichopora*. The soft coral *Sinularia* was extremely abundant, while two other species of soft coral, *Sarcophyton* and *Lobophyton* were common. There were rare occurrences of a carpet anemone from the genus *Heteractis* and the giant clam *Tridacna maxima*.

PAL-15P

SE side coral gardens. High coral cover of *Montipora* and *Acropora* species. Macroinvertebrates were conspicuously absent, with the exception of the giant clam *Tridacna maxima,* which was quite common. The starfish *Acanthaster planci* was present but rare.

PAL-11

West side. Extensive reef habitat located on the western terrace of the atoll. There was abundant coral and *Halimeda* macroalgae. The only common macroinvertebrates were the hydrozoa *Gymangium*, *Stylaster*, and *Distichopora*. There was a rare occurrence of an unknown starfish and the giant clam *Tridacna maxima*. Soft corals of the genus *Sinularia* and *Sarcophyton* were seen commonly throughout the site.

PAL-01

Central south shore. The coverage of hard and soft corals was less at this site compared to other south shore reef locations. The only abundant macroinvertebrates were the hydrozoa *Gymangium*, *Distichopora*, and *Stylaster*. There were rare occurrences of giant clams and a single *holothuroid* species, *Bohadschia graeffei*, was recorded.

PAL-18

NW end of the western terrace. No marine invertebrate survey.

General Impressions

Palmyra Atoll possesses a wealth of habitats with varying degrees of macroinvertebrate diversity. The southeastern and western terrace reef areas possessed great abundances of hard and soft corals, as well as various macroinvertebrate species. The dominant macroinvertebrate species group in these areas was hydrozoa. A species of *Dendronephtya* soft coral was noted on southeastern forereef locations, which had not been noted in previous surveys. The giant clam *Tridacna maxima* was noted in forereef habitats but was generally not very abundant and tended to be mostly individuals averaging less than 20 cm in size. Tridacnid clams were recorded to be common at a single unique backreef habitat located on the southeastern portion of the atoll. This sheltered area known as the “Coral Garden” had the greatest abundance of giant clams than any habitat at Palmyra Atoll. The crown-of-thorns starfish *Acanthaster planci* was rarely seen at any habitats.

Marine Alien Species Survey

In addition to the regular coral reef surveys, a focused survey for marine alien species was conducted at four Palmyra lagoon sites. This involved qualitative surveys at two sites with man-made structural components, such as seawalls and dock pilings, and two sites located at islands without these structures. In all four locations surveys were conducted from the exposed intertidal zones down to subtidal locations. The subtidal locations for the lagoon islands were down to 1 meter deep, while the seawalls and dock pilings locations involved subtidal depths to 5 meters. Organisms that were not identified in the field were collected for further analysis in the laboratory.

PAL-22B, Marine alien species survey site

North side of western lagoon at the end of the airstrip. Survey conducted from the shoreline to 3 meters depth. Habitat was composed of concrete and dredge rubble along the shoreline with a sand bottom. A series of old dock pilings was located within 5 meters of the shoreline and were included in the survey. Four species of sponge were common throughout the site on the man-made and natural substrate. Gastropods were abundant

from the shoreline to 1 meter deep. The shoreline was inhabited predominately by the gastropods *Littoraria pintado, Littoraria scabra, Nerita picea, Nerita plicata,* and *Nerita polita*. Subtidally the gastropods *Cypraea moneta* and *Strombus maculatus* were common. The dock pilings had extensive growth of the cup coral *Tubastrea coccinea,* the macroalgae *Caulerpa cf. racemosa,* and the alien hydroid *Pennaria disticha*. It is suspected that two of the four species of sponge present are alien species.

PAL-24B, Marine alien species survey site

Survey conducted on the dock and seawall located on the north side of the western lagoon. Habitat was dominated by the macroalgae *Galaxura* and three species of sponge. Two of the sponge species are possibly alien species. Intertidally exposed sea wall and dock piling substrates were occupied by the gastropods *Littoraria pintado, Littoraria scabra, Nerita picea, Nerita plicata,* and *Nerita polita*. Subtidally sponges and *Galaxura* were dominant. The black-lipped pearl oyster *Pinctada maragaritifera* was common and the cephalopod *Octopus cyanea* was rare. Another macroalgae, *Caulerpa cf. racemosa,* was also common throughout the site.

PAL-27, Marine alien species survey site

Southern part of western lagoon near channel at Sand Island. A survey from the shoreline to a subtidal depth of 1 meter was conducted. Sand Island was created from dredge spoil and has become colonized with coconut palms and *Pisonia* trees. The shoreline is composed of consolidated dredge spoil and unconsolidated coral rubble. The subtidal zone is composed of sand and coral rubble. The shoreline was dominated by gastropods and sesarmid and xanthid crabs. The coconut crab *Birgus latro* was commonly seen foraging at the edge of the shoreline. Subtidally, the gastropod *Cypraea moneta* was dominant and two species of sponge were common. The two sponge species recorded from this site were also recorded at sites 24B and 22B and are possibly alien species. The holothuroids *Holothuria edulis* and *Holothuria atra* were very abundant in the subtidal zone at 1 meter depth but were mostly absent beyond this depth.

PAL-28, Marine alien species survey site

Northern section of the central lagoon. This was a protected cove with a shoreline composed of coral rubble and sand. The subtidal zone was fine silty sand with periodic carbonate structure. The shoreline was dominated by sesarmid crabs and small coenobitid land hermit crabs. The subtidal area had a large abundance of two gastropod species, *Cypraea moneta* and *Strombus maculatus*. Also present were the holothuroid species *Holothuria atra* and *Stichopus chloronotus*. One species of sponge that is possibly an alien species was seen on the hard carbonate structure at the site but was not common. This sponge was one of the species recorded at both 24B and 22B.

General Impressions

One confirmed species and two suspected species of marine invertebrates were identified as alien species during cursory examination. The confirmed species was the hydroid *Pennaria disticha,* which has been spread throughout the tropical Pacific by anthropogenic mechanisms. The two suspected species were both sponge species. These will require detailed taxonomic analysis since it is difficult to identify these organisms in the field. The confirmed alien hydroid was only found in conjunction with the sites with

seawall and dock piling structures, whereas the two sponge species were found at all sites surveyed in subtidal depths to 2 meters.

3. Kingman Reef

Site Narratives

KIN-11

SE side outer reef. Reef slope with high abundance and diversity of hard and soft corals. There was also great abundance of macroinvertebrates. The sea urchin *Echinothrix calamaris* was very abundant, as were the hydrozoa *Distichopora* and *Stylaster*. The holothuroid *Bohadschia graeffei* was rare, as was the giant clam *Tridacnid maxima*. An anemone from the genus *Phymanthus* was recorded at the site but was rare.

KIN-13

SE side outer reef. Reef slope with high abundance and diversity of hard and soft corals. There were many species of macroinvertebrate present but the most common were the hydrozoa *Distichopora* and the urchin *Echinothris calamaris*. There was a rare occurrence of the anemone hermit crab *Dardanus gemmatus* with its commensal anemone *Calliactis polypus*. The cowrie *Cypraea tigris* was common at this site, while the giant clam *Tridacna maxima* was rare.

KIN-03

Patch reef central southern lagoon. Dome shaped patch reef with extremely abundant and diverse macroinvertebrate community. The dominant macroinvertebrate species were tridacnid clams, holothuroids, and anemones. Tridacnid clams were very abundant throughout the site from 45 feet up to the crest of the patch reef. The dominant species was *Tridacna maxima*, while *Tridacna squamosa* was rare. Echinoderms were also abundant with a total of 8 species of holothuroid, 3 species echinoid, and 2 species of asteroid visibly present. Crown-of-thorns starfish were present but rare.

KIN-5P

Eastern lagoon. Slope of a reticulated reef with abundant tridacnid clam populations. Echinoderms were also very abundant throughout the site. The urchins *Echinostrephus calamaris* and *Tripneustes gratilla* were common, as was the crown-of thorns starfish *Acanthaster planci*. The anemone *Heteractis malu* was also common below 20 feet. In shallow water at the crest of the reef there were two different species of sea urchin common, *Heteractis mammilatus* and *Diadema*.

KIN-16P

Eastern lagoon. Shallow lagoon reef with extremely abundant giant clam populations. With the conjunction of the giant clams, the urchin *Diadema* was extremely abundant throughout the site. The large anemone species *Heteractis magnifica* was recorded as common throughout the site.

KIN-12

Southern lagoon backreef area. The dominant macroinvertebrates at the site were holothuroids and tridacnid clams. Giant clams were dominant from shallow depths to 50 feet, while the holothuroids were only abundant from 30 to 50 feet. At the shallow depths above 30 feet the urchins *Diadema*, *Echinothrix*, and *Heterocentrotus* were more numerous than holothuroids.

KIN-08

Northern lagoon backreef. Giant clams and soft corals dominated the macroinvertebrate community. There were three common soft corals throughout the site, which were *Sarcophyton*, *Lobophyton*, and *Sinularia*. The giant clams were common from shallow depths to 50 feet, as were the soft coral species. Holothuroids were recorded commonly from 30 to 50 feet, but urchins were common from shallow depths to 50 feet. The urchins *Heterocentrotus*, *Diadema*, and *Echinothrix* were common at shallow depths but only the latter two species were present below 30 feet. Crown-of-thorns starfish were seen commonly throughout the site.

KIN-10

North lagoon patch reef. This dome-shaped patch reef was dominated by tridacnid clams, anemones, and urchins. The common anemone species were *Heteractis magnifica* and *Heteractis malu*, with the former being extremely abundant. The urchins *Heterocentrotus* and *Echinothrix* were common from shallow depths to 35 feet. Crown-of-thorns starfish were seen commonly throughout the site.

KIN-07

Central lagoon patch reef. Shallow dome-shaped patch reef with abundant giant clams and urchins. There were two numerous urchin species, *Echinothrix* and *Diadema*, and were seen from shallow depths to 35 feet. Crown-of-thorns starfish were seen commonly throughout the site.

General Impressions

Kingman Reef exhibits an extreme abundance and diversity of macroinvertebrate species within all forereef, backreef and patch reef environments. All the habitats of this atoll possess abundant macroinvertebrate populations that appear to be intact and undisturbed by anthropogenic activities. The tridacnid clams *Tridacna maxima* and *Tridacna squamosa* are both present, with the former being the most common. Giant clams were present in all habitats surveyed, with lagoon patch reef possessing the greatest densities (see table below). Echinoderms were also a well represented component of the macroinvertebrate complement throughout the atoll. All classes of echinoderm, with the exception of crinoids, were well represented throughout all habitats but the greatest abundance was in the lagoon environment.

The crown-of-thorns starfish, *Acanthaster planci*, was recorded at all sites surveyed at Kingman Reef. The potential for a large outbreak in the near future appears quite high. This is true for both forereef and lagoon habitats. The table below shows that the greatest population densities, determined from data collected from rapid ecological assessment sites, are located in lagoon patch reefs.

	FORE REEF		BACK REEF		LAGOON PATCH REEF				
Site	KIN-11	KIN-13	KIN-12	KIN-08	KIN-03	KIN-5P	KIN-16P	KIN-10	KIN-07
Tridacnids/m2	0.04	0.02	0.16	0.12	0.55	0.74	5.32	1.66	1.01
COTS/m2	0.004	0.006	0.03	0.03	0.01	0.08	0.004	0.012	0.006

Appendix E: Towboard Team Activity Summary *(Molly Timers, Kyle Hogrefe, Stephani Holzwarth, Joe Laughlin)*

A. Methods

Shallow water habitats were surveyed using pairs of towed divers on towboards equipped with a downward high resolution digital still camera with dual strobes (benthic towboard) and forward-looking digital video camera (fish towboard) to quantify habitat composition and complexity and abundance and distribution of ecologically and economically important fish and macroinvertebrate taxa. The downward-looking camera was maintained ~1 m off the bottom and was programmed to photograph benthic substrate every 15 seconds. The diver-observer on the benthic towboard observed and recorded habitat composition and characteristics (substrate percentages) and tallied conspicuous macroinvertebrates (Crown-of-thorns, urchins, sea cucumbers, giant clams, octopus, lobster), and marine debris over 5-minute ensembles. The diver-observer on the fish towboard recorded fish greater than 50 cm total length along a 10-m swath for 4 minutes followed by a 1 minute all around search in the same 5-minute ensembles. Both towboards were instrumented with precision temperature and depth recorders (Seabird SBE39). GPS positions, temperature and depth were recorded every 5 s along each transect. The data were downloaded and presented in an ArcView GIS and overlaid on high resolution IKONOS imagery.

B. Results

1. Jarvis Island

During this survey period, a total of 11 towed-diver surveys were conducted around Jarvis covering approximately 20 km of habitat.

***Benthic Observations*:** (Molly Timmers and Kyle Hogrefe)

We observed the dominant habitat to be continuous reef along the west and south shore, extending to the southeast point along the eastern terrace. Carbonate rubble was the dominant habitat along the north shore and the eastern terrace. For the 11 towed-diver habitat surveys, less than .1% of the coral appeared pale. The towed-diver surveys revealed few conspicuous macroinvertebrates; no giant clams (*Tridacna sp.*) or crown-of-thorns starfish (*Acanthaster sp.*) were observed. The algae present along the west side of the island appeared to be dominated by coralline algae with little to no fleshy or turf algae. Only in the southwest did we observe soft corals, specifically *Sinularia sp.* and *Lobophyton sp.*

***Fish Observation*:** (Joe Laughlin and Stephani Holzwarth)

The twin spot snapper (*Lutjanus bohar*) was the most commonly observed fish, larger than 50 cm TL with 327 observations made during this survey period. The gray reef shark (*Carcharhinus amblyrhyncos*) was the second most commonly encountered with 325 sightings. Also commonly observed was the blacktongue unicornfish (*Naso hexacanthus*) with 164 sightings. On the southeast terrace of Jarvis Island a whale shark (*Rhincodon typus*) was observed off survey. Other notable observations included the

sighting of a school of 16 great hammerhead sharks (*Sphyrna mokarran*) over 300 cm TL and the frequent sighting of large manta rays (n = 26). A large school of blackfin barracuda (*Sphyraena qenie*) with over 100 individuals over 75cm TL was recorded off the southwest corner of the island. Turtles were also commonly encountered with 76 observations in 11 tows.

2. Palmyra Atoll and Kingman Reef

During this survey period, a total of 39 towed-diver surveys were conducted around Palmyra and Kingman. Of these, 21 were conducted around Palmyra Atoll covering ~ 41 km of habitat, and 18 tows were conducted around Kingman Atoll covering ~ 39 km of habitat. We resurveyed all previous tows conducted during the 2001 and 2002 cruises in Palmyra, with the exception of two tows conducted on the eastern terrace in 2001. In addition we conducted three new tows along the western terrace. All previous tows conducted during the 2001 and 2002 field season at Kingman were resurveyed. In addition we conducted three new tows, two along the northeast backreef slope and one along the southern backreef slope.

***Benthic Observations*:** (Molly Timmers and Kyle Hogrefe)

Palmyra Atoll

We observed the dominant habitat to be continuous reef around the entire island and western terrace. In addition to continuous reef, we observed areas of patch reef in the center of the western and eastern terraces and carbonate rubble areas in the south, southwest, and northwest. For the 21 towed-diver habitat surveys, 0.68% of the coral habitat appeared pale and 0.03% appeared white. Along the northern shore there was evidence of a storm damaged reef, and the coral habitat appeared to be dominated by soft corals. The towed-diver surveys revealed few conspicuous macroinvertebrates, no crown-of-thorns starfish (*Acanthaster sp*.) were observed, and only 11 giant clams (*Tridacna sp*.) were recorded.

Kingman Atoll

We observed the dominant habitat for all tows to be continuous reef. In addition to continuous reef, we observed areas of carbonate rubble along the northeastern, eastern, and southern backreef slopes. For the 18 towed-diver habitat surveys, 1.5% of the coral habitat appeared pale and 0.94% appeared white. Within the southeast backreef lagoon, 38% of the coral habitat appeared pale. The southwestern and northeastern forereefs appeared to be dominated by soft corals. A total of 821 crown-of-thorns (COT) starfish (*Acanthaster sp*.) were recorded equating to 45 COT per tow. During the 2002 survey year there were 380 recorded COT equating to 35 COT per tow. We resurveyed the 2002 tows and recorded 571 COT which was a 66% sighting increase and equated to 52 COT per tow. Two new tows this year along the northeastern backreef slope recorded a total of 241 COT. Along these tows, 13% of the coral habitat appeared white due to predation, and the live coral composition in this area seemed to be dominated by *Porites sp*. Over 25,000 giant clams (*Tridacna sp.*) were observed with 85% of them located in the southeast backreef lagoon. The giant clams appeared to compose nearly 50% of the benthic composition in this area.

***Fish Observation*:** (Stephani Holzwarth and Joe Laughlin)

The twin spot snapper (*Lutjanus bohar*) was the most commonly observed fish, larger than 50 cm TL with 1117 observations made during the survey period, 414 at Palmyra and 703 at Kingman. The rainbow runner (*Elagatis bipinnulata*) was the second most commonly observed fish over 50 cm TL at Palmyra, although this high figure was due to observing several large schools of over 50 individuals. The second most abundant nonschooling fish at both Palmyra and Kingman was the Pacific steephead parrotfish (*Chlorurus microrhinos*) with 158 and 282 observations, respectively. The gray reef shark (*Carcharhinus amblyrhyncos*) was the most commonly observed shark at both Palmyra and Kingman with 245 total sightings over 100 cm TL. Other notable observations included seven sightings of giant hammerhead shark (*Sphyrna mokarran*) over 300 cm TL at Palmyra and the sighting of a 400-cm tiger shark (*Galeocerdo cuvier*) at Kingman.

Appendix F: Oceanography Team Activity Summary *(Ronald Hoeke, Kevin Wong, Jamie Gove, Megan Moews, Phil White)*

A. Methods

Oceanographic assessments of the reef ecosystems are accomplished by:

1. Continuous recording of surface and subsurface water temperatures as a function of depth during all towed-diver operations, providing a broad and diverse spatial temperature sampling method.
2. Shallow Water CTDs (max 90 m) at regularly spaced intervals around each island, sample vertical profiles of temperature, salinity, and turbidity providing indications for water masses and local sea water chemistry changes.
3. Continuous recording of near surface water temperatures, salinity, and fluorometry from the *Oscar Sette*, providing a broad spatial surface sampling of water properties.
4. Deep Water CTDs (max 500 m) and Acoustic Doppler Current Profiler (ADCP) transects circumnavigating the island, which provides information on overall oceanographic structure, including chlorophyll and dissolved oxygen.

Long-term oceanographic monitoring around the islands and atolls is accomplished by deployment and retrieval of a variety of internally recording and near real-time telemetered instrument platforms. These instruments include:

1. Sea Surface Temperature (SST) Buoy: Surface buoy measuring high resolution water temperature. Data is telemetered in near-real time.
2. Ocean Data Platforms (ODPs) measure subsurface temperature and salinity, current profiles, directional spectral wave energy, and high precision tides.
3. Subsurface Temperature Recorders (STRs) measure high resolution subsurface temperature.
4. Satellite Drifters, Lagrangian devices providing surface layer circulation information and water temperature which telemeter data in near real-time.

B. Results

1. Jarvis Island

Jarvis Island, centered at latitude 0º22’ S, longitude 160º00’ W, is located on the northern fringes of the mean position of the westward flowing surface South Equatorial Current (SEC) and uniquely situated in the mean path of the subsurface eastward flowing Equatorial Undercurrent (EUC). Compared to SEC waters, the EUC is a relatively cold, nutrient rich, fast flowing current. Strong flow of the EUC past the island results in upwelling of cold waters on the western side of Jarvis Island. On past research surveys to Jarvis, colder temperatures of 1-3˚ Celsius have been measured to the west compared to those in surrounding waters. This injection of cold, nutrient rich water stemming from the EUC impinging on the slope of this island likely has important ecological impacts on the local coral reef ecosystem.

Mooring Team operations during the period of 26-27 March 2004 on cruise OES0404, at Jarvis Island, are summarized in the following tables:

Location	Shallow water CTD casts	Radiometer casts
Jarvis	35	-

Mooring Deployments/Recoveries					
Instrument type	**Action taken**	**Location**	**Date (UTC)**	**Serial number**	**Depth (m)**
STR	Deploy	W. Jarvis	26-Mar-04	3933179-1190	6.4
STR	Deploy	E. Jarvis, SST Deployment location	26-Mar-04	3933179-1189	12.2
STR	Deploy	N. Jarvis	26-Mar-04	3933179-1191	9.8
STR	Deploy	S. Jarvis	26-Mar-04	3933179-1192	9.8
ODP	Recover	SW Jarvis	26-Mar-04	267-002	14.6
ODP	Deploy	SW Jarvis	26-Mar-04	267-004	14.6
SST	Recover	E. Jarvis	08-Feb-04	268-006	13.1
SST	Deploy	E. Jarvis	08-Feb-04	268-009	13.1

CTD Casts:

Thirty shallow water CTD casts with a maximum depth of 35 meters were performed following a 30-40 meter contour on the perimeter of Jarvis Island. Five additional shallow water casts extending down to 90 meters were performed roughly a half mile offshore on the north, west, and south sides of Jarvis.

Mooring Deployments and Recoveries:

STR deployments were generally colocated with selected REA sites. A small subsurface float was attached directly to the reef near the STR location to assist in locating the instrument in the future at most deeper deployment sites.

ODP Subsurface Mooring #267-002, deployed at latitude 0°22.7487'S, longitude 160°0.9281'W in March 2002, was successfully recovered. Instrument appeared in good condition, but heavily fouled, primarily with coralline algae. The settlement plates and racks were missing and no debris from them was located in the vicinity. All Sontek data was successfully recovered; the instrument was still recording when recovered. With the SBE37 data successfully recovered, data collection ceased 12/09/03 due to low voltage (battery power), providing 21 months of temperature and salinity data. Replacement ODP Subsurface Mooring #267-004 was deployed on the original concrete block anchor with new settlement plates.

SST Buoy #268-006 originally deployed on the Jarvis eastern terrace, at latitude 0°22.524'S, longitude 159°58.422'W in March 2002, was no longer there. The original anchor and almost all the line, including the splice at the line-buoy connection were found at the deployment location, and it is assumed that some high energy event caused the line to chafe through at this point. Data telemetry suggests that the buoy was in the

vicinity and transmitting up to January 2004. A search was made along the coast of Jarvis for the buoy, but it was not located. A new, more protected deployment location for the replacement buoy, SST Buoy #268-008, was sought in the eastern terrace area, but no other good sand patches such as the existing deployment location were found. Consequently, the new SST buoy was deployed at the same location. Black electrical tape was tightly wrapped around the line at the lateral attachment point of the buoy to try and reduce chafe at this point.

Preliminary Observations

Preliminary analysis of shallow water CTD data shows generally warm and well mixed waters to the southeast, east, and north sides of Jarvis, with temperatures ranging from 27.0 to 27.3˚ Celsius. Unfortunately, a substantial portion of the data from the shallow water CTD casts performed to the west and southwest are missing, or were never recorded due to an unknown technical failure with the SEACAT 19+. The casts in this vicinity that do contain data have temperature profiles that show signs of upwelled EUC waters, with temperatures 0.3 to 0.7˚C colder compared to equal-pressure temperatures in surrounding waters.

Temperature time series downloaded from ODP Subsurface Mooring #267-002 shows a temperature maxima of near 30˚C during October 2002; overall temperature for the following year are noticeably lower, with a minima of near 22˚C during April 2003. This seems to correlate roughly with ENSO indices: warmer temperatures during El Nino conditions and cooler during La Nina. Also of interesting note are large temperature changes, up to 5˚C, apparently on semidiurnal timescales, which appear to happen only during cooler periods. This was initially assumed to be noise, but the large temperature changes exhibited by the SBE37 data are confirmed by the Sontek ADP temperature data. These large temperature fluctuations are presumably due to large internal tides leading to an extreme shoaling of the thermocline. Larger overall wave heights during 2002 and the first part of 2003, compared to the last ~2/3 of 2003, are also apparent in the ADP data.

2. Palmyra Atoll and Kingman Reef

Palmyra Atoll, centered at latitude 5º53’N, longitude 162º06’W is an atoll with a morphologically complex lagoon system and drowned reef terraces on both the eastern and western ends. This location is near the mean center of the atmospheric Intertropical Convergence Zone (ITCZ), allowing Palmyra to receive extreme amounts of annual rainfall (150 to 200 inches per year). This location is also near the mean boundary between the South Equatorial Current (SEC) and the Equatorial Counter Current (ECC).

Kingman Reef, centered at latitude 6º25’N, longitude 162º24’W is a large atoll whose entire western side is drowned, with a relic reef crest at about 10-20 meters. Unlike Palmyra, it has no significant emergent reef or land and its lagoon appears to be extremely well flushed. Although Kingman is less than 40 nmi (68 km) northwest of Palmyra, it can be surmised that its position is sufficiently different to put it in a different mean oceanic current regime.

Oceanographic assessments at all of the islands are accomplished by:

5. Continuous recording of surface and subsurface water temperatures as a function of depth during all towed-diver operations, providing a broad and diverse spatial temperature sampling method.
6. Shallow Water CTDs (max 90 m) at regularly spaced intervals around each island, sample vertical profiles of temperature, salinity, and turbidity providing indications for water masses and local sea water chemistry changes.
7. Profiling Radiometer casts (max 40 m), at select locations, sample vertical profiles of discrete bands of visible light and natural florescence, both downwelling and upwelling. These measurements provide insight into such properties as chlorophyll concentration, light availability, and reflectance signatures of substrate.
8. Continuous recording of near surface water temperatures, salinity, and fluorometry from the *Oscar Sette*, providing a broad spatial surface sampling of water properties.
9. Deep Water CTDs (max 500 m) and Acoustic Doppler Current Profiler (ADCP) transects circumnavigating the island, which provides information on overall oceanographic structure, including chlorophyll and dissolved oxygen.

Long-term oceanographic monitoring around the islands is accomplished by deployment and retrieval of a variety of internally recorded and near real-time telemetered instrument platforms. These instruments include:

5. Coral Reef Early Warning System (CREWS) Buoys: Surface buoys measuring a number of meteorological and oceanographic parameters which telemeter data in near-real time.
6. Sea Surface Temperature (SST) Buoy: Surface buoy measuring high resolution water temperature. Data is telemetered in near-real time.
7. Ocean Data Platforms (ODPs) measure subsurface temperature and salinity, current profiles, directional spectral wave energy, and high precision tides.
8. Subsurface Temperature Recorders (STRs) measure high resolution subsurface temperature.
9. Satellite Drifters, Lagrangian devices providing surface layer circulation information and water temperature which telemeter data in near real-time.

Mooring Team operations during the period of 29 March–4 April 2004 on cruise OES0404, at Palmyra and Kingman, are summarized in the following tables:

Location	Shallow water CTD casts	Radiometer casts
Palmyra	55	7
Kingman	45	5

Mooring Deployments/Recoveries					
Instrument type	**Action taken**	**Location**	**Date (UTC)**	**Serial number**	**Depth (m)**
STR	deploy	Palmyra, Eastern Terrace, REA Site PAL-25.	29-Mar-04	3933179-1369	9.1
STR	recover	Palmyra Coral Gardens, REA Site PAL-15P	29-Mar-04	3924343-0379	1.5
STR	deploy	Palmyra Coral Gardens, REA Site PAL-15P	29-Mar-04	3933179-1370	1.5
CREWS-ENH	deploy	Palmyra, West Lagoon	30-Mar-04	307-001	8.8
CREWS-ENH	recover	Palmyra, Cooper's Island	30-Mar-04	261-003	8.8
STR	deploy	Palmyra, Southwest Terrace	31-Mar-04	3933179-1196	15.2
STR	deploy	Palmyra, Lagoon, near N. dock	Apr-02-04	3933179-1194	3.7
STR	deploy	Kingman, Old RCM-9 Anchor, South Pass	Apr-02-04	3933179-1193	6.7
STR	deploy	Kingman, Old CREWS Buoy Anchor, REA Site KIN-16P	Apr-02-04	3933179-1367	7.6
CREWS-STD	recover	Kingman, E. Lagoon	Apr-02-04	262-006	8.0
SST	deploy	Kingman, E. Lagoon, REA Site KIN-16P	Apr-02-04	268-010	7.0
RCM-9	recover	Kingman, South Pass	Apr-02-04	414	7.6
STR	deploy	Kingman, Inside South Reef, REA Site KIN-12	Apr-03-04	3925285-0503	3.4
STR	deploy	Kingman, Inside North Reef, REA Site KIN-8	Apr-05-04	3933179-1195	5.5
STR	deploy	Kingman, Outside South Reef, REA Site KIN-13	Apr-03-04	3933179-1368	6.4

Mooring Deployments and Recoveries

STR deployments were generally colocated with selected REA sites. Small subsurface floats were attached directly to the reef near the STR location to assist in locating the instrument at most deeper deployment sites. More detailed descriptions of other moorings' deployments and recoveries are below under the area headings.

Palmyra

Enhanced CREWS Buoy #261-003 was successfully recovered from Cooper Island, Palmyra; it had be removed from its original deployment location and brought ashore when it was found that the swivel in the original configuration was a failure point. Many thanks are due to Matt Lange and others on Palmyra for their assistance in this operation. Existing settlement plates, accumulator, and all other mooring hardware from the original deployment were still at the deployment location on the old anchor in a small western arm of the lagoon. They were removed. Replacement Enhanced CREWS Buoy

#307-001 was deployed at this same location. Existing settlement plates, still on the original anchor, were removed and new settlement plates attached in N, S, E, W array on anchor. The existing (old) anchor appeared to be in good shape and was left in place and used for the new CREWS buoy. Buoy #307-001 uses the new Iridium system for data telemetry, rather than the old ARGOS system, allowing for greater data throughout with each transmission. Matt Lange (on-site coordinator for The Nature Conservancy) is very interested in the data and requested that we forward the daily data file from this buoy to him as it is difficult for him to access the web to get the data. Automatic e-mail forwarding of the datafile will be set up upon our return to Honolulu.

STR #3924343-0379 (temperature and pressure) was successfully recovered from the coral gardens in the shallow eastern lagoon. This was the very first STR deployed by CRED and the first to be recovered after a 2-year deployment. Although the unit was heavily fouled with coralline algae and small *Acropora* colonies, 22 months of data were recovered. The instrument was replaced by a new STR at the same location: REA Site Pal-15P.

Kingman

Standard CREWS Buoy #262-006 had broken free from its original mooring location (latitude 6°23.544'N, longitude 162°20.531'W) in the eastern most end of the lagoon. The last transmission CRED received from the telemetered buoy was in late 2002 in the vicinity of Papua New Guinea, and so it is unlikely that it will be recovered. The original anchor, settlement plates, and accumulator/mooring hardware were still in place. Inspection of the mooring hardware indicated that the swivel was indeed the point of failure. The settlement plates were recovered and all old mooring hardware was removed. The original CREWS buoy anchor was left in place as a platform for new settlement plates and an STR.

SST Buoy #268-010 was deployed 3 meters NE of original CREWS buoy deployment location, at latitude 6°23.5448'N, longitude 162°20.5275'W, in the eastern most end of the lagoon. This slightly different deployment location was selected due to concerns about the line chafing on surrounding large *Porites* heads at the original CREWS buoy deployment location.

Aanderaa RCM-9 Current Meter #414 was successfully recovered from the small reef pass on the southern side, at latitude 6°22.9619'N, longitude 162°21.5567'W. The unit was heavily fouled, primarily with coralline algae. The unit was still recording data when recovered and the full time-series of both currents and temperature were downloaded. The original anchor was left in place and used as a deployment platform for an STR.

Preliminary Observations

Palmyra

Preliminary analysis of shallow water CTD shows surrounding waters during survey time to have a mean temperature of 28.0˚C and mean salinity of 34.7 PPT. Waters were generally well mixed and extremely clear (transmissivities >80%), with the exception of the lagoon where CTD casts showed a much greater range of temperatures

and salinities, displaying evidence of relatively high stratification, and in some cases, higher amounts of particulates or DOM in the water column. Close investigation of CTD profiles outside the lagoon reveals subtle but consistent spatial differences. Waters along the northern side of the atoll are warmer (~0.2˚C) and less saline (~0.2 PPT) than those on the southern side of the atoll. These two water types appear to be mixing on the eastern and western terraces where CTD water property differences are not so distinct. Additionally, there is strong evidence of warmer, less saline lagoonal water intrusion along the southern side. This develops a hypothetical picture of slightly denser water upwelling and mixing along the southern side of Palmyra, modified by intrusions of warmer, fresher waters from the lagoon.

STR data recovered from the eastern coral gardens show large diurnal temperature changes, not unexpected given the shallow, sheltered deployment location. Daily water temperature changes of >4˚C were observed.

Kingman

Preliminary analysis of shallow water CTD shows surrounding waters are extremely well mixed, with a mean temperature of 28.1˚C and mean salinity of 34.6 PPT. Total differences in salinity were less than 0.1 PPT, and all transmissivities were greater than 80%. Higher water temperatures and slight stratifications in the top 5-10 meters of the water column were observed in the most sheltered areas of the east lagoon and just southwest of the small area of emergent south reef. These observations appear to be diurnal influences, as they are not accompanied by changes in salinity and are not apparent in CTD cast collected in the early morning. Other than these areas, CTD characteristics inside the reef or relic lagoon were nearly indistinguishable from those outside the lagoon, which leads to the assumption that Kingman Reef's lagoonal waters are nearly pelagic most of the time.

The Aanderaa RCM9 current meter that was recovered from the small southern Pass at Kingman shows modal water velocities around 20 cm/s (approximately 0.4 knots) and maximum velocities of around 75 cm/s (approximately 1.5 knots). Modal directions were centered roughly along both directions of the axis of the channel and appeared to be primarily driven by semidiurnal tides, except for certain periods, which appear to be dominated by outflow. It can be surmised this happens during exceptionally large swell events. The temperature time series recovered from the instrument appears not to be affected greatly by diurnal variation. Maximum recorded temperatures reach approximately 30.2˚C and minimum temperatures are approximately 27.5˚C.

Appendix G: Habitat Mapping/Night Operations Team Activity Summary *(Megan Moews, Marc Lammers, Phil White)*

1. Jarvis Island

Night operations conducted at Jarvis March 25-27, 2004, during cruise OES0404, included EK60 bioacoustics lines and conductivity-temperature-depth (CTD) casts. Night operations at Jarvis did not include Towed Optical Assessment Device (TOAD) deployments, QTC (benthic acoustic signature) data collection, nor Acoustic Doppler Current Profiler (ADCP) transects. The *Oscar Elton Sette* surveyed within 0.17 nmi of the island and was unable to find depths less than 139 meters. In order to run TOAD deployments and QTC successfully, depth should be no more than 100 meters. CTD casts were conducted in place of TOAD and QTC operations, which normally took place between 1830 and midnight to minimize interference with small boat-dependent daytime operations and overhead costs for shipboard personnel. These were followed by bioacoustics lines from 2400 to 0600. ADCP transects did not take place, as the ADCP was still not functioning. A table summarizing night operations data collected March 25-27 on cruise OES0404 follows:

LOCATION	No. TOAD deployments	No. video segments	QTC files	km of ADCP	Hrs of bioac.	CTD casts
Jarvis	0	0	0	0	12	13
Total	0	0	0	0	12	13

Twelve deepwater CTD casts were conducted during night operations and one CTD cast took place on the afternoon of March 27. CTD casts were conducted twice at each of the north, east, south, and west stations; once at each of the northwest, southwest, and southeast stations; and two separate casts were taken at the southwest apex of the two bioacoustics lines.

The oceanographic current structure near Jarvis is highly dynamic, but is dominated by two main currents, the surface westward flowing South Equatorial Current (SEC) and the subsurface eastward flowing Equatorial Undercurrent (EUC). CTD Profiles to the north, west, southwest, and south exhibit a step like change occurring abruptly near 90-100 meters and extending 30-50 meters into the water column. These profiles show characteristic water properties of the EUC with distinctively marked decreases in temperature and dissolved oxygen coinciding with an increase in salinity. The CTD cast to the east of Jarvis exhibited a much different profile than those in surrounding waters. Temperature, dissolved oxygen, and salinity show a homogenization of the upper 100 meters, with a more gradual change in values over the next 50 meters. This apparent lack of a distinctive EUC signature is likely due to the island causing an obstruction of flow, creating a wake like an effect “downstream” from the mean subsurface flow pattern.

Fluorometric values were extremely elevated in all CTD casts and correlated rather closely with temperature profiles. Casts to the east showed a uniform chlorophyll

signature in the upper 100 meters, whereas casts on all other sides of Jarvis exhibited a slight increase in values with depth and a subsurface maxima occurring near 50 meters. The comparison of the daytime cast with the nighttime cast at the southwest nearshore station showed a large diurnal signal, with chlorophyll values in the upper 50 meters, much greater during nighttime hours.

Bioacoustics:

Transit from Samoa to Jarvis Island

Echosounder data on the deep scattering layer were collected during the 4 days of transit between Samoa and Jarvis Island. EK60 recordings were made approximately every 2 hours for 30 minutes during daylight hours and continuously between midnight and sunrise, totaling 46.5 hours of echosounder data collection. Casual examination of the data revealed that a pronounced layer occurs during the day at a depth of 400-500 meters and that this layer rises to the top 100 meters at night. A more detailed analysis is likely to reveal any latitudinal variations in density and migration that are present.

Jarvis Island

Echosounder surveys were conducted along two transect lines on the southern and western shores of Jarvis Island during the afternoon of March 26 and the night/morning hours of March 27. Transect lines were run approximately 0.2–0.3 nmi from shore in waters 300-600 m deep. Each line was run three times at approximately 00:00, 02:30, and 05:00. Daytime control transects of each line were run at 14:00. Echosounder data were also collected during 12 of the 13 CTD casts conducted while at Jarvis.

A nonquantitative assessment of the data revealed a clear diurnal trend in the occurrence of a layer of surface-associated biomass. The layer is concentrated in the top 100 meters, just above the thermocline and centered on the chlorophyll maximum. The layer's nighttime density was more or less constant along both transect lines. During the day, the layer was absent from the southern transect, but occurred densely in a patch towards the northern end of the western transect. The biological composition of the layer is unknown.

2. Palmyra Atoll and Kingman Reef

Night operations conducted at Palmyra and Kingman March 29–April 5, 2004, during cruise OES0404, included Towed Optical Assessment Device (TOAD) deployments, QTC (benthic acoustic signature) data collection, EK60 bioacoustics lines and conductivity-temperature-depth (CTD) casts. TOAD deployments were generally conducted between 1830 and midnight to minimize interference with small boat-dependent daytime operations and overhead costs for shipboard personnel after midnight. QTC data was collected during this time and bioacoustics lines and CTD casts followed TOAD deployments from 2400 to 0600. Bioacoustics control lines were also run during the day. Acoustic Doppler Current Profiler (ADCP) transects did not take place, as the ADCP was still not functioning. A table summarizing night operations data collected March 29-April 5 on cruise OES0404 follows:

Location	# TOAD deployments	# Video segments	# of QTC segments	# CTD deployments	Bioacoustics data (hrs)
Palmyra	20	19	20	12	18
Kingman	0	0	0	8	12
Total	20	19	20	20	30

TOAD/QTC

TOAD deployments at Palmyra were challenging as a result of the steep bathymetry surrounding most of the island in conjunction with the offsets in charted positions in the Nobeltec navigation software. TOAD was deployed twenty times in conjunction with QTC data collection; however, the bottom was not located during one deployment on the southeast side of the island. Deployment locations were chosen to sample areas of varying depths and location, as well as to obtain ground truthing material in conjunction with QTC data collected in 2002. The majority of the TOAD deployments took place on the western bank of the island where depths of 7 to 25 meters were detected below the ship's keel. Much of the western bank that was examined at these depths consisted primarily of extensive amounts of diverse live corals which sometimes alternated with fields of coral rubble and encrusting coralline algae with small patches of live coral. The benthic topography in these areas was rough textured with many overhangs and large coral heads. On the steep northwestern and southeastern slopes of the island, with winds coming from the northeast, TOAD was able to capture video along contours ranging from 40 to 80 meters in depth. These areas were dominated by coral rubble, sand, and encrusting coralline algae, with very little live coral.

Night operations at Kingman did not include Towed Optical Assessment Device (TOAD) deployments, QTC (benthic acoustic signature) data collection, nor (ADCP) transects. The *Oscar Elton Sette* surveyed within <0.2 nmi of the shallow sides of the atoll and was unable to find suitable depths where the ship would be able to conduct TOAD and QTC operations in a safe manner. In order to run TOAD deployments and QTC successfully, depths should be no more than 100 meters. The steep sides at Kingman were not conducive to such operations. According to the Nobeltec navigation chart, towable depths could be found on the interior of Kingman and possibly the southwestern bank. However, because the charts proved to be quite different from the actual sites, the risk of taking the *Sette* into such areas was too high. Thus, CTD casts and bioacoustics lines were conducted in place of TOAD and QTC operations at Kingman.

The suspected connector problem in the TOAD video setup that had caused a frequent 2-8 second blanking out on the video display during OES0401-OES0402 was fixed prior to OES0404. After extensive troubleshooting, the problem turned out to be a faulty character generator, which was in turn replaced before the final leg of the cruise. Thus there should be no blank segments on the recorded video from OES0404.

CTD Casts

During night operations at Palmyra and Kingman, 20 deepwater CTD casts were conducted. CTD casts were conducted at each of the north, east, south, west, northwest,

northeast, southwest, and southeast stations. These stations correspond with stations used in 2002 as well stations used in the past and possibly future ADCP transects in these areas. Twelve CTD casts were taken at Palmyra, 3 of which were in conjunction with bioacoustics lines. At Kingman, eight CTD casts were conducted. On the night of 04/03/2004, during operations at Kingman, the CTD winch began experiencing technical difficulties. Operations were put on hold until the problem could be further investigated the following day. Regardless of the problem, CTD casts continued to take place for the duration of the time at Kingman, and data were collected from all stations.

Palmyra, which is located approximately six degrees above the equator, lies within the boundary of the westward flowing South Equatorial Current (SEC) and the eastward flowing Equatorial Counter Current (ECC). The boundary between the two opposite flowing currents creates a zone of intense shear, resulting in convective mixing, eddy formation, and the injection of deeper waters to the surface. This influx of deep water is accompanied by an increase in nutrients, therefore enhancing productivity surrounding Palmyra. This can be seen across the board in the data collected at each of the CTD stations around the atoll. Each station demonstrates high surface productivity with mixed layers carried down to approximately 115 meters deep at which point the thermocline begins, the exception being the north CTD, which exhibits a mixed layer down to approximately 90 meters. Profiles in the north and west show an inflection in the thermocline with a mixed layer between 120 and 150 meters. In the south and southeast, the profile is similar; however, the vertical drop indicating mixed layers begins at approximately 150 meters and takes place in roughly 20-meter layers. For the most part, the chlorophyll maximum reflected the depth of the thermocline, and all of the CTD data around Palmyra, with the exception of the north and the south, showed a decrease in salinity at the surface. There was also one cast influenced by sunlight, as it was taken during the day and demonstrated a decrease in chlorophyll at the surface, and another cast showed an increase in temperature and oxygen at the surface and a decrease in salinity while it was raining.

The CTD casts from Kingman showed similar patterns to Palmyra. Kingman profiles showed a shallower thermocline starting at approximately 100 meters. Data from the northeast and east showed the thermocline beginning at approximately 90 meters, whereas the north stood out with a thermocline beginning at a depth greater than 120 meters. Throughout the profiles, the north proved to be very different. Basically, from the south to the north there was a decrease in thermocline depth and an increase in salinity; however, at the north and northwest CTD stations, the thermocline was deeper and there was a decrease in salinity. The north and northwest stations also showed a gradual decrease in temperature in the mixed layer, while the other stations maintained a steady temperature throughout the mixed layer. At most of the stations, the salinity tended to be mixed to 100 meters, but in the north and northwest it dropped before that from the surface to approximately 50 meters and again in the northwest at 100 meters. Also in the north and northwest, there was more of a chlorophyll drop at 90-100 meters. With the northwest CTD, the daytime effects could still be seen, as there was also a chlorophyll drop at the surface. It is uncertain whether the effects demonstrated in the CTD profiles were from the front of the island.

Bioacoustics

Palmyra Atoll

Echosounder surveys were conducted along six transect lines around the atoll between March 30 and April 1. Transect line lengths ranged from 2.5 to 5.0 nmi. Two lines were run along the edge and on the southwestern bank of the atoll, one along the southern shore, one along the edge of the southeastern bank, one along the northeastern edge of the bank, and one along the northern shore. All but the northern and northeastern transects were run multiple times during the same and/or successive nights, as well as during the day. Echosounder data were also collected during the 12 CTD casts conducted while at Palmyra, as well as opportunistically on seven occasions while transiting through locations of interest.

A nonquantitative assessment of the data revealed that a dense community of mid-water sound scattering organisms exists around the entire perimeter of the atoll at night. This community resides primarily along the atoll's steep slopes at a depth of 100-130 meters and is centered on the thermocline. A secondary, less dense layer of organisms occurs above the thermocline in patches. Opportunistic observations made during transits perpendicular to the atoll's edges indicate that both layers extend well offshore (2-3 nmi) along the southwestern side, but that they are restricted to less than 1 nmi offshore along the other sides. A speculative explanation for this observation is that the southwestern side is enriched by nutrients flowing out of the lagoon more so than the other sides. The main channel into the lagoon lies on the southwest corner and the prevailing tradewinds blow from the northeast, probably creating a net movement of water towards the southwest. Coincidentally, several observations of melon headed whales (*Peponocephala electra)* were made along this side of the atoll. This species is known to feed primarily on squid, which are typically part of the sound scattering layer.

Kingman Atoll

Echosounder surveys were conducted along four transect lines along the southern and eastern sides of the atoll between April 2 and April 4. Two transect lines were run parallel to the atoll's slopes and two were perpendicular. The two parallel transects were conducted at 18:00, 21:00, 0:00, and once towards the middle of the day. The perpendicular transects were run at 19:00 and at 1:00. Echosounder data were also collected during the eight CTD casts conducted while at Kingman, as well as opportunistically on one occasion while transiting along the southwestern corner of the atoll.

A qualitative assessment of the data collected indicates that a sound scattering layer is conspicuously missing along most parts of the eastern and southern sides of the atoll. Both night and daytime transects revealed only dispersed patches of mid-water organisms. These patches were very localized and ranged in depths between 80 and 130 meters. The most prominent patch was observed along the southwestern corner of the atoll. This again coincided with the entrance to the primary channel into and out of the atoll (as in Palmyra).

Summary and Discussion

The echosounder data collected at the three sites visited reveal that each location is quite distinct in the density and distribution of the mid-water biomass occurring there. Jarvis and Palmyra appear to be much more productive than Kingman. Furthermore, Palmyra supports a dense, thermocline-associated community that was not observed at either Jarvis or Kingman.

It is interesting to note that oceanographically and ecologically the three locations are quite distinct. Jarvis Island is the top of a steep pinnacle rising from the ocean floor. It is located almost at the equator and is fed by upwelling from the equatorial undercurrent and is also a major bird colony. Nutrient inputs from these two sources are probably important factors contributing to the mid-water productivity observed there. Palmyra, on the other hand, is a forested network of islets that also supports a significant bird population. Nitrogenous and organic outflows from the terrestrial ecosystem are likely an important factor behind the productivity observed there, particularly along the southwestern side where the lagoon's waters flow out. Finally, Kingman Atoll is influenced by neither the equatorial undercurrent nor any terrestrial-based ecosystem. A minimal or reduced influx of nutrients at Kingman may explain the lack of sound scattering biomass encountered there.

Appendix H: Terrestrial Team Activity Summary *(Alex Wegmann, Mark Rauzon)*

1. Jarvis Island

Jarvis Island National Wildlife Refuge Survey
Mar. 26-27, 2004

Alex Wegmann and Mark Rauzon spent approximately 24 hours on Jarvis Island doing seabird surveys and ancillary observations for the U. S. Fish and Wildlife Service (USFWS). We covered roughly half of the 2-square-mile island in the allotted time, made some significant findings, and took 10 new GPS measurements (both Track and Waypoint each) for mapping bird colonies. The island was very dry and the vegetation was brown, except the mat-like succulent *Sessuvium*. About 100-150 bottlenose dolphins were seen around the atoll.

At approximately 0930, we landed the USFWS jet boat/Avon easily on the east shore. This site was chosen because Coxswain Jonathan was experienced with this site. It is reliable for a landing on a sandy beach afforded some wave protection by a coral reef, although this site could be problematic at times. Several green sea turtles were seen in the immediate vicinity.

After establishing camp, communicating with the ships, and eating lunch we began our surveys at 1130. Heading north, we noted the west shore berm in a large continuous Masked Booby colony. The birds were mostly in the early stages of nesting, establishing territories, copulating, and on eggs. We also began to take GPS measurements of Red-footed Booby and Great Frigatebird colonies and also took nesting phenology observations. At the northwest corner, we discovered a very large aggregation of Blue Noddies (formerly called Blue-gray Noddies). This is the most significant finding of the survey, for this roosting group numbered approximately 200 birds. This species is often found in very small flocks and finding 50 would be significant. The high number at one site was remarkable, and in all, we physically counted 274, although the island population is likely double that. This observation is significant because 20 years ago there where no Blue Noddies nesting here when feral cats were present. Since the cat eradication in 1983, the populations have built up, and this rapid increase may be related to the oceanic upwelling around Jarvis that promotes their planktonic food sources.

We noted Sooty Terns were mostly finished breeding. There appears to be two populations with different seasonality. The finishing flock had a few juveniles still attended by parents, and there were many carcasses of juveniles that had likely starved to death.

At sunset, many terns were arriving on the island and swirling in a courtship flight. Several hundred thousand were estimated to be in flight over Jarvis.

We visited the lighthouse and saw the USFWS sign and found no evidence of trespass. The northeast landing channel looked flat and easily negotiable. Gray-backed Terns were found nesting throughout the traditional camp site, with thousands of sooty terns swirled about it making our southeast side camp preferable. Heading east, we found the Phoenix Petrel caller, a solar power tape player designed to attract this bird to Jarvis Island. The unit was not working so we retrieved it to return it to Honolulu for repair. Speakers and the photovoltaic unit were left in place.

There was a very large Lesser Frigatebird colony estimated to hold about 3000 birds. Their phenology was mixed; some were courting, some were on eggs, and some were feeding post-fledging chicks.

At 1640 we returned to camp to replenish our supplies and gear up for night work. After dark we basically repeated our survey, looking for nocturnal procellarids or tubenoses.

At the north coast we discovered Audubon and Christmas Shearwater species in flight.

We began to search for Polynesian or white-throated Storm-petrels in the coral rubble on the beach crest but found none. House mice are possible predators of storm petrel eggs.

Mice were uncommon and were very quick to flee our lights. One was seen gnawing a dead Sooty Tern carcass. Some eggs appeared to show gnawing marks, suggesting mice eat eggs probably after they are abandoned.

Moving inland we searched for shearwater colonies and located two sites. We physically counted 41 Wedge-tailed Shearwaters at one colony. Among the tropical dark phase Wedge-tailed Shearwaters was one light phase from the subtropics. They were calling from the surface and from in their burrows that were dug into humus under mats of Sesuvium. There were also 20 Christmas Shearwaters counted on the surface, including one large downy chick. The occurrence of Christmas Shearwater in these relative high numbers also demonstrates population recovery post cat eradication. These sites were GPS'd and mapped on the next day, as was a guano quarry site where an Audubon Shearwater was seen.

We reached our camp at 2200 and rested until 0530.

At 0600 we contacted the NOAA ship *Oscar Elton Sette* and learned our pickup was scheduled for 1200. We broke camp in anticipation and resurveyed the shearwater colony and other bird colonies. We walked the beach along the south shore and collected mollusks samples for Scott Godwin of the Bishop Museum.

Pick up at 1200 went smoothly in spite of larger waves than at drop off.

BIRD POPULATION ESTIMATES FOR JARVIS ISLAND NWR	**actual counts*
SEABIRDS	
Wedge-tailed Shearwater (*Puffinus pacificus*)	41*
Christmas Shearwater (*Puffinus nativitatis*)	20*
Audubon's Shearwater (*Puffinus ilherminieri*)	4*
Polynesian Storm Petrel (*Nesofregetta fuliginosa*)	?
Red-Tailed Tropicbird (*Phaethon rubricauda*)	150
Masked Booby (*Sula dactylatra*)	5,000
Brown Booby (*Sula leucogaster*)	200
Red-Footed Booby (*Sula sula*)	750
Great Frigatebird (*Fregata minor*)	1,600
Lesser Frigatebird (*Fregata ariel*)	4,000
Gray-backed Tern (*Sterna lunata*)	1,100
Sooty Tern (*Sterna fuscata*)	1,500,000

BIRD POPULATION ESTIMATES FOR JARVIS ISLAND NWR	*actual counts
Brown Noddy (*Anous stolidus*)	10,000
Blue Noddy (*Procelsterna cerulea*)	650
SHOREBIRDS	
Bristle-thighed Curlew	15*
Wandering tattler	5*
Sanderling	3*
Pacific Golden Plover	2*
Ruddy Turnstone	3*

2. Palmyra Atoll

Itinerary

Mar. 29

1230-Launch Avon with Rauzon and Wegmann.

Meet Palmyra representatives of The Nature Conservancy, Matt and Elizabeth Lange, check into quarters, orient to facilities. Tour atoll islands with Matt to learn tides, flats, and passes.

Mar. 30

0800-Assist Scott Godwin with invasive marine invertebrate surveys by using USFWS Avon for transport and snorkeling assistance.

1200-Begin Booby survey in atoll. (Note island population of Red-footed Boobies was recently estimated to be 25,000, and the largest outside of the Galapagos, but in 2002 a population crash occurred) Red-footed Booby surveys made using Avon. Nests are on *Tournefortia* shrubs near the islet edge. Counts are made as we motor slowly along an islet.

1500- Coconut Crab survey on Sand Islet.

Mar. 31

0800- Continue booby surveys around islets.

Survey islets for study sites for Wegmann's research. Observe *Pisonia* die-off.

1300- Tour guide *Sette* personnel on shore leave.

1530- Resume booby survey.

1700- Visit Sand Islet for coconut crabs.

April 1

0800- Boat maintenance, resurvey Dudley Islet, study Bristle-thighed curlews.

1445-Rauzon embarked on *O. E. SETTE*; Wegmann remained on Palmyra.

Palmyra Findings

	RFBO	BRBO	MABO	RTTB	RUTU	BTCU	WATA	Notes
March 30								
Leslie Islet	109	0		0		3		Rat-free
Dudley	113	1	0	0				Rat-free
Ainsley	25	1	0	2				Rat-free
Sand Island	278				16	2	1	Coconut Crabs
Mary Jane	270	22	1					
Causeway	106	53	5					
March 31								
N/S Paradise Causeway	113	4				2		
S. I. Chain S end to r. slough	321							
N and Mid section of N/S Causeway	221	8	0	1				
Extreme S. I. Separate parts	89	7						
TOTAL	**1635**	**96**	**6**	**3**	**16**	**7**	**1**	

Ecological Damage on Palmyra

It appears that the importation of vegetable plants, perhaps potted papayas, soil, etc. may have originally brought a scale insect, white flies, and at least nine species of ants to Palmyra. Within the last 10 years, the scale insect has infested the *Pisonia grandis* forests described as recently as 2001 as the last undisturbed forest in the Pacific (Maragos, 2001). The rapid decline of these balsa-like rainforest trees is caused by the tree's dropping its leaves in response to an infestation. Eventually the tree dies and is blown over in high winds. (Scale insects are honeydew producers, husbanded by ant species in a commensal relationship).

With this process in flux, a ship rat (*Rattus rattus*) eradication was begun in 2002. The effort required large groups of volunteers cutting tracks through the vegetation every 50 meters on all the islets of the atoll. The exchange of bait stations, machetes, and other equipment among and between islets, plus the physical perturbation may have exacerbated the spread of the scale insects throughout the atoll. (Note: the complete loss of the *Pisonia* trees at Rose Atoll also occurred at post rat eradication). The rat eradication effort was terminated before all the rats were eliminated, but not before a significant knockdown occurred. During this period, palm nuts sprouted that were otherwise predated by rats. Because the *Pisonia* forest declined and the dense shade provided by the canopy diminished, the dense undergrowth of fern and sprouting palm nuts may change the microclimate of the forest floor. The forest ecology is jeopardized by the loss of the giant trees, potentially affecting coconut crabs that shelter in their roots and trucks and Black Noddies that nest in the upper branches.

Ant elimination experiments have begun, but the crab populations will also suffer significant loss if this undertaking proceeds on a large scale. Crab herbivory studies are beginning to be conducted by UH graduate student Alex Wegmann. Rat populations are no longer controlled and only the most isolated islets may remain rat free. Coconut sprout control should be instituted where appropriate and coconut free islets are established to allow native vegetation to grow without nutrient competition and shade from the coconuts.

Questions

- Were bait buckets moved from island to island? I don't think so - stations were permanent.
- Did ants infest the bait buckets?
- Was a crab island eradication attempted anywhere else before? Interference by coconut crabs was high.
- Bait buckets ceased to be effective - they were avoided by rats.
- Was the hole placed too high?
- Will reef nutrient enhancement be limited if the *Pisonia* forest is eliminated?

3. Kingman Reef

Itinerary

April 2

1100- Launch Safe Boat to take snorkelers to northwest isle. Rauzon disembarks on NE isle for 45 minutes.

April 4

1300-1530: Visit to SE isle of Kingman Reef. Survey for seabirds and insects. One Wandering Tattler found. Collected shells for Scott Godwin, Bishop Museum. Collected dolphin skull for positive identification. No terrestrial insects found.

Survey

Kingman Reef (latitude 6º 22' N, longitude 162º 22 W), which is about 33 miles northwest of Palmyra Atoll, is a submerged triangle about 9 by 5 miles in size. Only the eastern tip is above water, and there are two isles. The NE isle surveyed is about 100 meters long, 3 meters wide at the center, and 2 meters high. The rubble island is made up of heaped up clamshells and coral pieces; all shells are pulverized into pieces; and a core beach is bleached gray, reminiscent of ancient shores noted on Jarvis Island.

Vegetation

Two coconuts had sprouted on the NE isle and lie side by side on the high point of the isle; they appeared to be natural seed dispersion. A coconut tree trunk lies in decay and a *Pisonia* trunk? was also on the upper beach.

Invertebrates

I searched the NE isle for a "hopping insect" (a beach amphipod) in vain and found only baby *Grapsid* crabs and these were too fast to capture barehanded.

A representative sample of shells was collected for Scott Godwin, Bishop Museum. All were in poor condition due to the battering the beach must receive regularly.

Birds

Three Masked Boobies, two Great Frigatebird females, two Brown Boobies, one Wandering Tattler, and one Pacific Golden Plover were on the NE isle. One Wandering Tattler was found on the SE isle.

Pollution

A large tar ball about 2 feet in diameter was congealed around pieces of shell and coral. A photo was made. A large bamboo pole with net filled with rubble was on the upper beach slope. About 25 plastic bottles and other similar debris were noted; however the appearance was one of an empty beach.

Pelagic Bird Observations

Observations made on the ship's bridge wings were conducted at least 6 hours a day while underway. All birds, flying fish, and marine mammals were recorded. We collected data from March 21 to 25, March 28, and April 5 to 7. Over 360 observations of birds and fish were made; no mammals were sighted. Hourly ship position and weather were also recorded. Pelagic bird observations will continue for the duration of the expedition.